

THESIS/
REPORTS
IRVING,
J.S.

agreements
ity
to

WESTFORNET

MONTHLY ALERT

Edition SEP 1983

Item No. 126

File co-op agreements

LOAN COPY "2"

FISH RESOURCES IN THE GOSPEL-HUMP
AREA OF CENTRAL IDAHO AND POTENTIAL
IMPACTS OF FOREST MANAGEMENT ACTIVITIES

AL-33 Bookplate
(1-63)

NATIONAL

**A
G
R
I
C
U
L
T
U
R
A
L**



LIBRARY

LIBRARY FILE COPY
INTERMOUNTAIN STATION
OGDEN, UT.

LOAN COPY "2"

WESTFORNET

MONTHLY ALERT

Edition SEP 1983

Item No. 126

File coop agreements

FISH RESOURCES IN THE GOSPEL-HUMP AREA OF CENTRAL IDAHO
AND
POTENTIAL IMPACTS OF FOREST MANAGEMENT ACTIVITIES

Final Report

for
Cooperative Agreement No. 12-11-204-11
Supplement No. 96

to
Intermountain Forest and Range Experiment Station
USDA, Forest Service
Moscow, Idaho 83843

SH177
L63 F5

by

J.S. Irving, B. Shepard, T.C. Bjornn, N. Horner and R.R. Ringe
Idaho Cooperative Fishery Research Unit
College of Forestry, Wildlife and Range Sciences
University of Idaho
Moscow, Idaho 83843

January 1983

TABLE OF CONTENTS

Page No.

LIST OF FIGURES	iii
LIST OF TABLES	vi
INTRODUCTION	1
STUDY AREA DESCRIPTION	3
Geology and Soils	3
Study Streams	5
Undeveloped Drainages	5
Developed Drainages	9
METHODS	11
Habitat Assessment	14
Quantity of Available Habitat	14
Quality of Available Habitat	17
Fish Abundance	20
Fish Movement	23
RESULTS	25
Habitat	25
Quantity of Available Habitat	25
Quality of Habitat	30
Fish Abundance	37
Species Composition	37
Fish Densities	47
Fish Densities by Habitat Type	56
Distribution of Fish by Habitat Type	68
Estimate of Fish Population Size	70
Fish Movement	74
MODELS	77
SnowSed Model	77
Fisheries Model	77
Sediment-Habitat Relationships	79
Habitat-Fish Response Curves	79
LITERATURE CITED	89
APPENDICES	93
Appendix A	93
Appendix B	98
Appendix C	107
Appendix D	124

LIST OF FIGURES

Page No.

Figure 1. Study streams in the Gospel-Hump area of central Idaho	4
Figure 2. Study streams in the Multiple Resource Development Area (MRDA).	8
Figure 3. A schematic diagram showing pocketwater, pool, riffle, run, and backwater habitats found in a typical stream section	12
Figure 4. Percentage of total number and percentage of total surface area (m ²) for each habitat type in Johns, Tenmile and Twentymile Creeks, 1979-1980	32
Figure 5. Substrate composition of pools and riffles for four sections of Tenmile Creek.	34
Figure 6. Substrate composition of pools and riffles for three sections of Twentymile Creek.	35
Figure 7. Substrate composition of pools and riffles in Mill, Johns and the West Fork of Twentymile Creeks.	36
Figure 8. Substrate composition of pools and riffles for sections 2 and 3 of Trapper Creek and section 1 of the West Fork of Red River.	37
Figure 9. Species composition in Johns Creek.	40
Figure 10. Species composition in four sections of Tenmile	42
Figure 11. Species composition in Twentymile (Sections 1-3) and West Fork of Twentymile (Section 4) Creeks	44
Figure 12. Species composition in Mill Creek.	45
Figure 13. Species composition in the West Fork Red River.	46
Figure 14. Species composition in two sections of Trapper Creek	47

Figure 15. Average fish densities (number per 100 m ²) in Johns, Tenmile (sections 1-4 combined) and Twentymile Creeks (sections 2 and 3 combined).	49
Figure 16. Average fish density (number per 100 m ²) in study sections of Mill Creek and West Fork Red River	50
Figure 17. Average fish densities (number per 100 m ²) in Trapper Creek (section 2 and 3 combined).	51
Figure 18. Average fish densities (number per 100 m ²) in in four sections of Tenmile Creek	53
Figure 19. Average fish densities (number per 100 m ²) in Twentymile (Sections 1-3) and West Fork of Twentymile (Section 4) Creeks.	55
Figure 20. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in Johns Creek, 1979	58
Figure 21. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in Johns Creek, 1981	59
Figure 22. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in Tenmile Creek, 1979	60
Figure 23. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in Tenmile Creek, 1981	62
Figure 24. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in Twentymile Creek, 1980	63
Figure 25. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in sections 1 and 2 of Twentymile Creek, 1981.	64
Figure 26. Mean fish density by habitat type and length class in Mill Creek during 1979 (upper) and 1980 (lower)	65

Figure 27. Mean fish density by habitat type and length class in West Fork Red River during 1979 (upper) and 1980 (lower) 66

Figure 28. Mean fish density by habitat type and length class in Trapper Creek during 1979 (upper), 1980 (middle) and 1981 (lower) 67

Figure 29. Population estimates and 95% confidence levels for all fish species in the MRDA portion of Johns Creek during the summers 1979 and 1981 72

Figure 30. Population estimates and 95% confidence levels for all fish species in the MRDA portion of Tenmile Creek during summers 1979 and 1981 73

Figure 31. Population estimates and 95% confidence levels for all fish species in the MRDA portion of Twentymile Creek during summers 1980 and 1981. 75

Figure 32. Relationship between substrate particle size and embeddednes level 80

LIST OF TABLES

Page No.

Table 1. Length of stream inventoried, gradient and valley and channel characteristics of study sections for streams in the South Fork Clearwater River Drainage	6
Table 2. Substrate size class, instream cover, and bank cover classifications used in assessing habitat types in the study streams.	19
Table 3. Comparison of number and percentages of habitat types for Tenmile, Twentymile and Johns Creeks using an actual, 20-pace and random survey. . .	26
Table 4. Results from pairwise comparisons for numbers and percentages of habitat types between actual counts, 20-pace and random sample methods done on Gospel-Hump area streams	28
Table 5. Estimated wetted surface area (m ²) and actual area measured (percentages in parentheses) in Johns, Tenmile and Twentymile Creeks, 1979, 1980 and 1981.	30
Table 6. Population estimates by species and length class in Johns, Tenmile and Twentymile Creeks (1979, 1980 and 1981) (95% confidence interval of estimate in parentheses)	71
Table 7. Embryo survival, summer rearing capacity, and winter carrying capacity of trout and age 0 steelhead and chinook salmon in Tenmile Creek on October 1 of each year modeled for alternatives A, B, D and E.	82
Table 8. Embryo survival, summer rearing capacity, and winter carrying capacity of trout, age 0 steelhead and chinook salmon in Twentymile Creek on October 1 of each year modeled for alternatives E and G.	83
Table 9. The percentage change and difference between the first and last year modeled in Tenmile Creek for alternatives A, B, D and E ("+" equals increase and "-" decrease)	85

Table 10. The percentage change and difference between the first and last year modeled in Tenmile Creek for alternatives B and E ("+" equals increase and "-" decrease) 87

Table 11. The percentage change and difference between the first and last year modeled in Twentymile Creek for alternatives E and G ("+" equals increase and "-" decrease). 88

INTRODUCTION

A 206,000 acre Gospel-Hump Wilderness Area in the Nez Perce National Forest, Idaho, was established by Congress on February 24, 1978 under The Endangered American Wilderness Act. Section 4 of this Act designates 92,000 acres as "management areas" and provides funds for research programs that ". . . includes detailed investigations concerning resident and anadromous fisheries resources (including water quality relationships). . . to provide findings and recommendations concerning integration of land management and development with the protection and enhancement of these fish and game resources. . .".

The purpose of this study was to document the existing status of the fish populations and habitats in selected tributaries to the South Fork of the Clearwater River, Idaho and to determine the effect of land management activities (logging, road construction, etc.) on fish habitat and abundance.

The objectives were to determine: 1) quantity and quality of fish habitat available to resident and anadromous fish, 2) fish abundance and habitat preference, and 3) the effect of management alternatives on fish abundance.

Land managers need reliable fish production information to evaluate management practices and choose future management plans. Platts (1976) stated that a methodology of high validity to determine aquatic habitat-fish production

relationships has not been developed due to the multivariate controls on the aquatic system.

In the past, fish scientists have relied on fish abundance estimates obtained in one or two "representative" stream sections to provide information for an entire drainage. While this method may be convenient, the extrapolation of one or two point estimates to describe an entire drainage may lead to gross errors. The method described in this report estimates both fish habitat and abundance using randomly selected areas throughout the stream.

Several models were developed to evaluate the effect of land management activities on sediment transport and deposition and fish habitat and abundance in the Gospel-Hump MRDA. Impacts of land management activities on salmonid populations and habitats are becoming increasingly evident. Land management activities such as logging and road construction generate sediment that is transported to the streams in overland flow. These activities often degrade stream habitat for salmonid populations. In a comprehensive review Cordone and Kelly (1961) summarize the evidence that fine sediment is detrimental to aquatic life in streams.

The research for this study was part of a baseline fisheries investigation funded by the USDA Forest Service through a contract with the Idaho Cooperative Fisheries Research Unit located at the University of Idaho, Moscow.

STUDY AREA DESCRIPTION

The study area is located southeast of Grangeville, Idaho in the South Fork of the Clearwater River drainage (Figure 1). The South Fork of the Clearwater River flows 100.6 km from its source at the junction of the Red and American Rivers near Elk City, Idaho, to join the Middle Fork of the Clearwater River at Kooskia, Idaho. The Clearwater River flows to the Pacific Ocean via the Snake and Columbia Rivers.

The majority of the precipitation in the area occurs in the winter as snow and during the spring as rain. Localized intense summer thunderstorms occasionally occur. These storms can transport a significant amount of sediment to the streams. However, the majority of sediment transport occurs during the spring peak flow event. The yearly gauged discharge of the South Fork of the Clearwater River recorded by the USGS at Stites, Idaho was 83 and 82 percent of normal for the 1979 and 1980 water years, respectively.

Geology and Soils

Kiilsgaard (1947) described the geology of the area as a transition zone between the Idaho batholith to the west and a gneissic zone to the east. This border zone contains rock which has been metamorphosed to varying degrees creating a mixture of several rock types. It is classified as part of the Belt series in which quartzite, quartz monzonite-granodiorite,

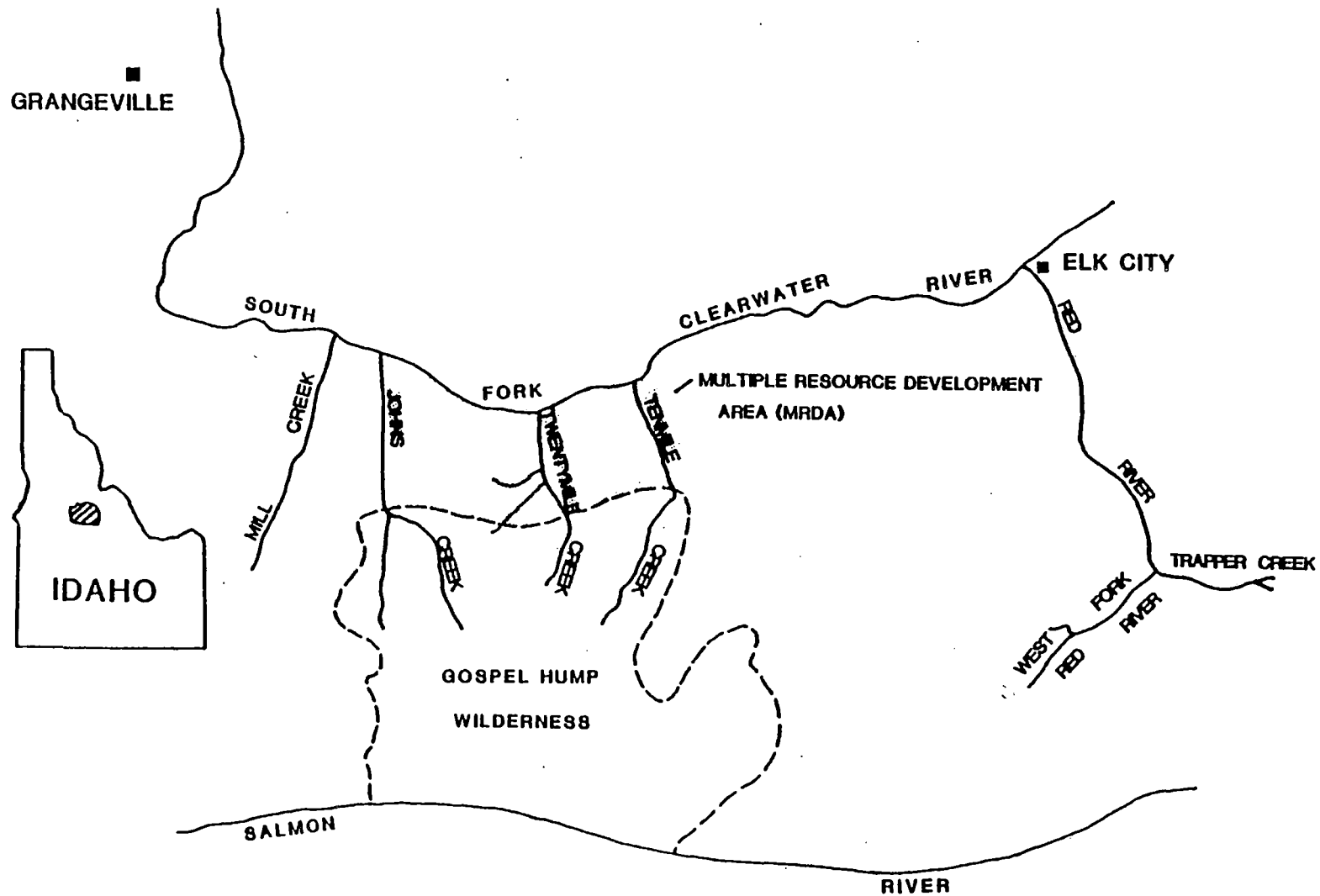


Figure 1. Study streams in the Gospel-Hump area of central Idaho.

and metamorphic schists and gneisses predominate. The area has been mined extensively for gold and is presently witnessing a renewed interest by commercial and recreational miners.

Soil development in the area is poor, consisting primarily of sand capped by ash originating from the volcanic activity of Mt. Mazama. The unconsolidated nature of the soil makes it highly erodible and harmful to fish when excessive amounts enter the streams.

Study Streams

Johns, Tenmile and Twentymile Creeks, located in the Multiple Resource Development Area (MRDA) were selected to observe fish abundance in undeveloped streams. Mill Creek, located west of Johns Creek and the West Fork of Red River, a major tributary to Red River were selected to observe the effects of past forest development on fish abundance and stream habitat. Trapper Creek, a tributary entering the West Fork of Red River from the east, was selected to observe the effects of in-progress roading and logging on the fish abundance and habitat.

We established stream sections on the basis of gradient, watershed morphometry and flow (Table 1).

Undeveloped Drainages

Johns Creek enters the South Fork of the Clearwater River

Table 1. Length of stream inventoried, gradient and valley and channel characteristics of study sections for streams in the South Fork Clearwater River Drainage.

Creek Section	Survey length (m)	Gradient (%)	Valley shape	Stream pattern
Trapper (Total length 9.7 km)				
Section 2	148	4	Steep Valley	Straight
Section 3	157	2	Meadow	Meander
Twentymile (Total length 19.6 km)				
Section 1	4,440	19	Canyon	Straight
Section 2	2,400	2	Meadow	Meander
Section 3	5,675	9	Steep Valley	Infrequent meander
West Fork of Twentymile (Total length 6.4 km)				
Section 4	2,000		Moderately steep valley	Infrequent meander
Mill (Total length 22.5 km)				
Section 1	125	3	Steep valley	Straight
West Fork Red River (Total length 17.7 km)				
Section 1	130	3	Moderately steep valley	Infrequent meander
Tenmile (Total length 32.2 km)				
Section 1	3,645	3	Steep valley	Straight
Section 2	750	4	Canyon	Straight
Section 3	2,370	2	Meadow	Infrequent meander
Section 4	3,445	5	Steep valley	Straight
Johns (Total length 27.4 km)				
Section 1	15,400	3	Steep valley	Straight

at river kilometer 56.3 and is 27.4 km in length (Mallet 1974). The MRDA portion of Johns Creek is 15.4 km long. The creek has a moderately steep channel gradient (approximately 32 m of rise per km of stream length) through-out the MRDA portion of the creek. The stream flows through an over-steepened valley with a narrow bottom (Table 1). The stream channel contained little fine sediment. Since Johns Creek has a uniform gradient and flow throughout the MRDA portion we selected five 1-kilometer sections for study (Figure 2).

Murphy and Metsker (1962) estimated 324 m² of suitable steelhead spawning area was available between the mouth of Johns Creek and a falls at stream kilometer 9.7. Murphy and Metsker reported this falls as an impassable barrier to upstream migrating anadromous fish. Our field crew found a falls 2 m high with an adequate jump pool below and catch pool upstream. We believe steelhead could migrate over these falls at high flows and chinook salmon passage would be possible in all but the lowest flow years.

Tenmile Creek enters the South Fork at river kilometer 76.6 and is 32.2 km in length (Mallet 1974). Murphy and Metsker (1962) estimated that the stream contained 12,055 m² of suitable steelhead spawning area and 6,727 m² of suitable salmon spawning area. The MRDA portion of Tenmile Creek (10.2 km) was divided into four sections based on gradient, valley shape, and stream flow (Figure 2).

Two natural sediment traps consisting of downed logs and

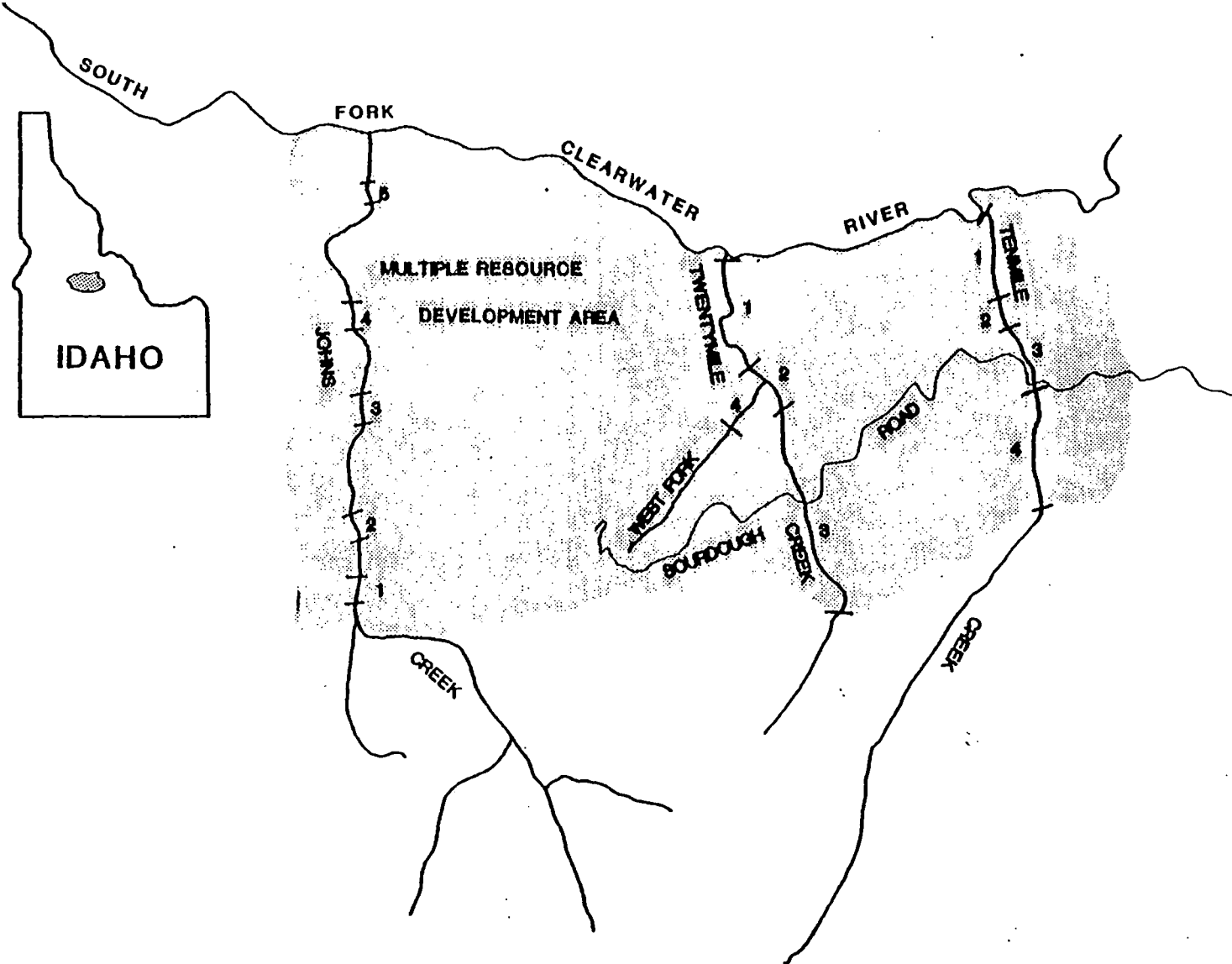


Figure 2. Study streams in the Multiple Resource Development Area.

debris behind which large volumes of fine sediment had accumulated were seen in Tenmile Creek. One was located just above the Gospel-Hump Wilderness boundary, the other approximately 200 m below the mouth of Sixmile Creek. A possible partial barrier to upstream migrating salmon was situated in section 2. The barrier consisted of a 2 m falls with a shallow pool below the falls which may not provide an adequate jump pool during low flows.

Twentymile Creek enters the South Fork of the Clearwater River at river kilometer 68.7 and is 19.6 km in length. The MRDA portion of Twentymile Creek (12.4 km) was divided into four sections (Figure 2). Sections 1-3 were located in Twentymile Creek proper and section 4 in the lower 2000 m of the West Fork of Twentymile Creek.

Developed Drainages

Mill Creek enters the South Fork of the Clearwater River from the south at river kilometer 50.7 (Figure 1). The creek is 22.5 km in length and has extensive forest development on the ridges and in the upper drainage basin. The stream has a steep gradient which Murphy and Metsker (1962) believed limited its importance for anadromous fish production. The study section was located approximately 500 m above the last bridge crossing of the creek by the Hungry Ridge Road and was 125 m long. The watershed was essentially undisturbed for 9.5 km along the stream above the study section. However, roading and

logging has occurred in the drainage above that point.

The West Fork of the Red River enters Red River from the south at river kilometer 22.5 (Figure 1). It is 17.7 km in length and contained 4,457 m² of suitable steelhead spawning area (Murphy and Metsker 1962). A paved road to Dixie Summit follows the river for over 9.5 km. The West Fork has numerous small meadows interspersed with areas of moderately steep gradient. The study section selected was situated in a moderate gradient stretch approximately 1.0 km above the mouth of Trapper Creek (river kilometer 6.4). The section was 130 m long and located immediately downstream from a natural meadow area. Logging and roading activity upstream from the study section occurred prior to and during the study.

Trapper Creek enters the West Fork of Red River at river kilometer 6.4 and is 9.7 km in length (Figure 1). We selected three section for study. Section 1 was located above the Nezperce Forest stage gauge upstream from the Trapper Creek Road bridge. After preliminary snorkeling, this section was dropped as a study section. We believe it contained reduced fish densities due to high angling pressure. Section 2 was 148 m long and began approximately 500 m above the Trapper Creek Road bridge. Section 3 was 157 m long and was located in a meadow area of Trapper Creek approximately 3.5 km above the West Fork of Red River.

METHODS

Fish abundance, species composition and habitat assessment in study streams was obtained using randomly selected transect. Most stream surveys are designed to collect information only on habitat parameters. In this study fish abundance was an integral part of the stream survey. At each randomly selected transect the type of fish habitat present in the stream was noted. Fish habitat was classified into six homogeneous habitat types: (1) pools, (2) riffles, (3) runs, (4) pocketwaters, (5) backwaters, and (6) side channels (Figure 3). Main habitat areas were classified as deep slow water areas (pools), fast shallow areas (riffles), areas of intermediate depth and high velocities (runs), and riffle areas interspersed with small pools (pocketwaters). Associated habitat types were classified as areas located off the main channel and out of the current (backwater) and areas of flowing water located off the main channel which contain less than 25% of the stream flow (side channels).

The criteria used in segregating habitat types was based on functional use of the areas by fish (Everest 1969, Jones 1975, Burns 1971) and the limitations of field sampling. Pools are used by larger fish as summer rearing habitat and are used by all fish as overwinter habitat (Everest 1969, Bjornn 1971, Bustard and Narver 1975a, Thorow 1976, Bjornn et al. 1977). Riffles have been identified as important food producing (Hynes 1972) and spawning (Reiser and Bjornn 1979) areas.

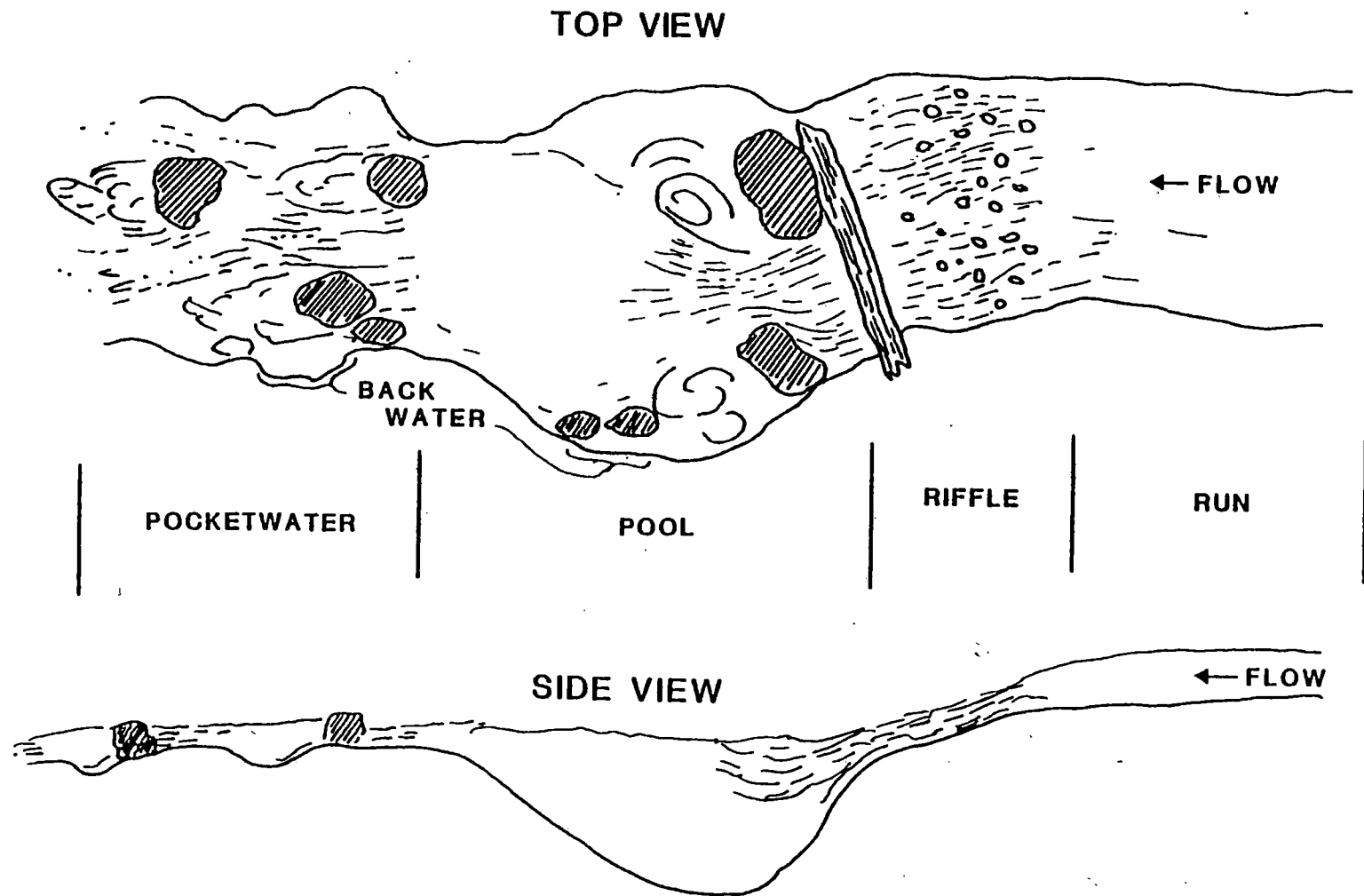


Figure 3. A schematic diagram showing pocketwater, pool, riffle, run, and backwater habitats found in a typical stream section.

Riffles also provide habitat for age 0 fish attempting to avoid predation. Everest (1969) found age 0 (young-of-the-year) steelhead trout and chinook salmon in fast water habitats. Jones (1975) reported the density of age 0 Atlantic salmon was twice as high in riffles as in pools. Pocketwater areas provided an excellent habitat mix of food-producing riffles and small holding pools for intermediate size fish. Backwater areas were found to be ideal habitat for age 0 fish, particularly chinook salmon (Mabbott, 1982). Backwater habitat also provided overwinter areas for juvenile salmonids (Eustard and Narver 1975b). Side channels were used exclusively by age 0 and intermediate size fish. Larger fish were generally unable to use side channels because of reduced flows that limited water depths, thus providing "safe" habitat for the smaller fish.

Salmon and steelhead are below carrying capacity in the South Fork of the Clearwater River drainage because of small escapements of adult fish in recent years. Natural production of fry was supplemented with hatchery fish to reduce the variability of natural seeding rates and bring the streams fish abundance up to carrying capacity.

Approximately 400,000 steelhead fry were released into Johns Creek from a helicopter near the Gospel-Hump Wilderness boundary on June 25, 1979. The fry were Dworshak National Fish Hatchery stock and average 31 mm at time of release (range, 26-33 mm). Johns Creek was seeded at a rate of (4.3 fry/m²) to

compensate for predation and other mortality factors. Everest (1969) found maximum densities for naturally produced steelhead fry of 2.4 fry/m². Mabbott (1982) observed fry densities as high as 44.1 fry/m² in a Lochsa River tributary where hatchery and wild fry were present. He stated that fry releases of 10 fry/m² may be necessary to fully seed rearing areas.

Approximately 10,000 spring chinook salmon fingerlings obtained from the Rapid River Hatchery were released into Tenmile Creek from the Sourdough Road bridge on June 20, 1979. These fish averaged 60 mm in length (range, 40-74 mm). Chinook fingerlings have been released into Tenmile Creek in past years as part of the Idaho Department of Fish and Game's program to reintroduce anadromous stocks. This release would not adequately supplement the natural chinook population. However, we believed that age 0 chinook numbers immediately downstream from the bridge would be near carrying capacity. Wild fry (30-45 mm range) were observed in this area of the Creek in 1979.

Habitat Assessment

Quantity of Available Habitat

We selected snorkel and habitat transects using the following methods:

- 1) Distances between sampling sites were randomly selected using a random numbers table.

- 2) Sites were located in the field by pacing the randomly predetermined distance along the stream. When within approximately twenty paces of the destination we would walk out of sight of the stream, removing as much sampling bias as possible resulting from selectively picking sample sites.
- 3) Flagging tape was used to mark the exact point paced to and marked 'HT' (habitat transect) along with an identification number. Each randomly selected area was classified into a specific habitat type (pool, riffle, run, pocketwater) based on water depth and velocity. Associated habitat types (backwaters and side channels) were included when present. Many researchers have used water depth and velocity to segregate stream habitat (Herrington and Dunham 1967, Lewis 1967, Burns 1971, Elser 1968, Jones 1975, LeCren 1958).
- 4) Flagging was placed at the upper and lower bounds of the habitat type and marked 'ST' (snorkel transect). Upper and lower bounds for the snorkel transect were selected on the basis of natural breaks (i.e., small cascades, a series of large rocks across the stream, a downed log, etc.) in the stream channel.

In 1979, a frequency of 10 sample sites/km were used for all of the sections in Tenmile Creek and the 1 km sections in Johns Creek. In 1980 a frequency of 25 sample sites/km was used for sections 2 and 3 in Twentymile Creek and 15 for sections 1 and 4. In 1981 all transects in Trapper, Tenmile, Twentymile, and Johns Creek were snorkeled to assess fish abundance.

We used several methods to assess the quality and quantity of the fish habitat. A line transect method was used to help evaluate the quality of each habitat.

In addition to estimates of various habitat types available in streams from the random transect method, estimates were also made using a systematic 20-pace transects and actual counts. The systematic 20-pace survey was used in the MRDA portions of Tenmile Creek in 1979 and 1980 and in Twentymile

Creek in 1980. We classified the stream section every 20 paces based on specific physical stream characteristics (i.e., depth, velocity, widths, and water surface appearance) into one of our established main habitat types (i.e., pool, riffle, run, or pocketwater) and into associated habitat types (i.e., backwater or side channel). In 1979, the survey was conducted by walking the bottom of Tenmile Creek in sections 3 and 4, and from a trail above the creek for sections 1 and 2. During 1980 the systematic 20-pace survey was repeated in Tenmile Creek, with the entire survey done from the creek bottom.

During 1980 we made complete counts of each "snorkel transect" sized habitat types in the MRDA portions of Tenmile and Twentymile creeks.

The mean area of each snorkeled habitat type was determined and multiplied by the actual number of that habitat type obtained from the complete counts. I believe this estimate of total area of each habitat type was the most accurate and was used to estimate fish population numbers in Tenmile and Twentymile Creeks.

A complete count of habitat types was not made in Johns Creek so an alternate method was used. The percentage of each habitat type from the random pace survey was multiplied by the length of the stream section and then multiplied by the average width of the habitat type to obtain the total area of each habitat type. Total surface area of each stream section was calculated by summing the estimated area of each habitat type

within that section.

We also used large-scale aerial photography to estimate the number and area of habitat types in Johns Creek. A flight of Johns Creek was made on August 22, 1979 using a Cessna 206 aircraft. We took photographs of Johns Creek using a Hulcher 70 mm camera with a 6-inch focal length lens using 2448 Ektachrome film and 60 percent overlap for stereoscopic viewing at a relatively large scale (1:3000). Two marker panels 3 m in length were placed 12.6 meters apart at 5 sites along the creek to verify the photographic scale. Habitat types were defined using methods described by Greentree and Aldrich (1976) and by verification on the ground.

Quality of Available Habitat

We used a line transect method modified from that described by Herrington and Dunham (1967) and Platts (1976) to describe the quality of available habitat. The following parameters were measured across the stream (perpendicular to the direction of flow and down the centerline of the stream) at one meter intervals (0.5 m intervals on streams less than 5.0 m wide) for each habitat transect: (1) depth to the nearest centimeter (cm), (2) water velocity 5.0 cm below the water surface to within 0.1 feet per second (fps) using a Marsh-McBirney electronic current meter, (3) a visual identification of the two most abundant substrate size classes using a classification system modified from Hart and Erusven

(1976), (4) a visual assessment of bank cover using a classification scheme developed by Mabbott (1982), and (5) a description of instream cover using categories described by Greentree and Aldrich (1976) (Table 2). Total stream width was also recorded for each transect.

We calculated mean values for average depth, thalweg depth, width, and average surface velocity across a transect. The percentage of each substrate size, instream cover, and overhead cover classification were calculated by habitat type and section for each stream. All observations across the stream channel were used for both the substrate size and instream cover classification. Only the observations nearest each bank were used to calculate percentage of the overhead cover.

Surface water velocities were measured because Everest and Chapman (1972) found good correlation between surface water velocity and fish location in streams. Wetted widths were recorded at each transect. Water and air temperatures were recorded each day we were at a particular site, and at selected sites throughout the season.

After analyzing 1979 habitat data we discovered that standard deviations for several parameters measured in pools were disproportionately high. Standard deviations for thalweg depth in pools ranged from 9.6 to 14.6, compared to 3.6 to 8.7 for the other habitat types. In 1980, a cluster sampling technique was used in Twentymile Creek pools to more accurately estimate pool habitat characteristics. Several habitat

Table 2. Substrate size class,¹ instream cover,² and bank cover³ classifications used in assessing habitat types in the study streams.

Substrate size

1. Silt or detritus - particulate organic matter
2. Sand - less than 1.5 mm in diameter
3. Pea gravel - 1.5 to 6.4 mm in diameter
4. Pebble - 6.4 to 63.5 mm in diameter
5. Cobble - 63.5 to 254.0 mm in diameter
6. Boulder, bedrock - larger than 254.0 mm

Instream cover

1. Aquatic vegetation
2. Logs, debris, or boulders (above water surface)
3. Logs, debris, or boulders (below water surface)
4. Man-made structures (bridge abutments, etc.)

Bank Cover

1. Undercut bank, log or root mass
 2. Brush overhang < 2 meters above water surface
 3. Brush overhang between 2 meters to canopy overstory
 4. Overstory canopy
 5. None
-

¹ Modified from Brusven and Hart (1975).

² From Greentree and Aldrich (1976).

³ From Mabbott (1979).

transects (at a frequency of one per 5.0 m of pool length) were measured across each pool.

Fish Abundance

We assessed fish abundance by computing fish densities (number fish/100 m²) for each habitat type snorkeled. Population estimates were made for each habitat type by species and length class using a simple ratio estimation procedure.

Transects were snorkeled by divers to assess fish populations. The divers would crawl upstream side-by-side in the middle of the stream channel, counting fish as they went. In wider streams (> 5.0 m), two passes were made. One pass was made up the middle by both observers each looking towards the bank on their side, and one pass by each diver up their respective sides of the stream. This method was found to be very effective. The observers did not recount fish since they were side-by-side on the first pass through and could discuss fish observations.

The fry and juvenile fish held their positions on the stream edges and were counted on the second pass through. It was difficult to distinguish between rainbow and cutthroat fry, so all fish less than 50 mm were designated as 0-50 mm trout. The exception to this was chinook salmon which are readily identifiable by both body shape and deeply forked caudal fin and mountain whitefish. It was also difficult to distinguish

between resident rainbow trout and juvenile steelhead. These fish were classified as rainbow/steelhead with the exception of those fish in Twentymile Creek which has an impassable falls near its mouth. The rainbow in this stream were considered resident trout. Rainbow-cutthroat trout hybrids were difficult to distinguish while snorkeling. Therefore, all fish that had the spotting pattern of rainbows were designated as rainbow trout/steelhead.

Mean fish densities and the 95% confidence intervals were calculated for each length class by habitat type and stream section. It was found that length classes were better than age due to overlapping ages within length classes. The length classes used were: 0-50 mm, 51-150 mm, and longer than 151 mm. Due to the early date of snorkel counts in Trapper Creek and West Fork of Red River (mid- to late June, before fry emergence from the gravel), the 0-50 mm trout were Age I, all other 0-50 mm trout were young-of-the-year.

We made populations estimates for each habitat type in each stream section by species and length class using a cluster sampling analysis procedure. A sampling unit consisted of one square meter. This allowed sample sites (snorkeled areas) of unequal areas to be weighted by area in the analysis. The number of fish observed in each sample site was entered into a data file by stream, section, habitat type, species and length class. These data were analyzed using a computer program and the PROC MATRIX SAS computer package at the University of Idaho

(SAS Institute 1979). The following equations were part of the computer program used to calculate fish densities, mean areas, population estimates and variances:

$$y = \bar{y} / m, \quad \text{Equation 1}$$

$$V(y) = (N - n) (Nm^2) (\bar{y} - y_m)^2 / n - 1, \quad \text{Equation 2}$$

$$m = \bar{m} / n, \quad \text{Equation 3}$$

$$V(m) = 1/n (N - n/N) (\bar{m} - m)^2 / n - 1, \quad \text{Equation 4}$$

$$T = (Nm) \bar{y} / m, \quad \text{Equation 5}$$

$$V(T) = N^2 (\bar{y}^2 (V(m)) + m^2 (V(y))), \quad \text{Equation 6}$$

where,

$\bar{y}$ = mean fish density (weighted by area),

$V(y)$ = variance of mean fish density,

$\bar{m}$ = mean surface area of the habitat type,

$V(m)$ = variance of the mean surface area,

T = total fish population,

y = fish number in the i th transect,

m = surface area of the i th transect,

N = total number of the habitat type
in the stream section,

n = number of habitat types sampled in
the stream section.

Populations estimated for each habitat type were summed for each section to obtain a total populations estimate for that section. The estimates computed for each section were summed to derive the estimate for the entire creek. The

variances of the estimates were summed in a similar manner, according to methods described by Vincent (1971). Standard errors for all estimates were calculated.

Equations 2, 4 and 6 are described by Scheaffer (1979). The covariance term for equation 6 can be disregarded since density to area correlation is nonsignificant (r^2 ranged from 0.001 to 0.028). The 95% confidence interval for the total fish population (T) was calculated using the following:

$$C.I. = 2 \sqrt{T}.$$

Equation 7

Fish Movement

Fish were trapped as they moved downstream during August, September, and October of 1980 in Johns and Tenmile Creeks to help evaluate the use of overwinter habitat by juvenile salmonids.

Traps were located approximately 200 m upstream from the mouths of the two creeks, and were operated continuously from August 21 to September 15. Traps were operated only on weekends from September 19 to October 26. Trap operation was hampered on two weekends when rainstorms raised water flows and debris clogged the leads causing them to drop, and in one instance water flowed over the Johns Creek trap. Trap operation was terminated on October 26 when maximum daily water temperatures did not exceed 6 C. Everest (1969) reported the

majority of juvenile salmonids observed in Idaho streams sought out overwinter habitat by the time water temperatures declined to 7 C.

The trap leads did not extend from bank to bank allowing passage of upstream migrating adult chinook salmon. Therefore, the trap catch represents relative numbers of outmigrating juveniles.

RESULTS

Habitat

Quantity of Available Habitat

The quantity of available habitat can be expressed as the number, frequency (percent) or the total surface area of each habitat type. The number of each habitat type for each stream section was computed from the 20-pace and random pace surveys by multiplying the percent of the habitat type, expressed as a decimal, by the total length of the stream section divided by the average length of that habitat type (Table 3).

Using actual counts for Tenmile and Twentymile Creeks as the true populations of habitats, we compared the other two methods for their ability to accurately represent the "true" populations of habitats. A multiple comparison test was used to test the hypothesis that the numbers and percentages of each habitat type were different (Table 4). There was no significant differences between the means.

In Johns Creek the percentage of habitat types calculated from the random pace survey and aerial photographs were almost identical (Table 3). The numbers of each habitat type counted from the aerial photographs were approximately half the numbers calculated using the random pace survey. The difference can be attributed to the frequent sharp turns in Johns Creek causing several sections of the creek to be missed and changes in photographic scale due to altitude differences. Also, long

Table 3. Comparison of number and percentages of habitat types for Tenmile, Twentymile and Johns Creeks using an actual,¹ 20-pace² and random³ survey.

		Number						Percentage ⁴				
Creek	Section	Year			Pocket	Back	Side					
	Method		Pool	Riffle	Run	water	water	channel	Pool	Riffle	Run	Pocket
Johns Creek												
Section 1												
Random	1979		468	299	116	589	177	95	31.8	20.8	7.9	40.0
Aerial	1979		263	143	60	285	35	52	35.0	19.0	8.0	37.9
Tenmile Creek												
Section 1												
Actual	1980		136	60	31	70	NC ⁵	NC	45.8	20.2	10.4	23.6
20-pace	1980		164	69	38	119	NC	NC	42.1	17.7	9.7	30.5
Random	1980		155	71	36	132	243	17	39.3	18.0	9.1	33.5
Section 2												
Actual	1980		51	11	7	15	NC	NC	60.7	13.1	8.3	17.9
20-pace	1980		54	7	0	23	NC	NC	64.3	8.3	0	27.4
Random	1980		63	12	0	14	0	0	70.9	13.5	0	15.7
Section 3												
Actual	1980		58	54	66	77	NC	NC	22.7	21.2	25.9	30.2
20-pace	1980		38	58	46	60	NC	NC	18.9	28.7	22.8	29.7
Random	1980		38	65	36	60	43	9	19.1	32.7	18.1	30.2
Section 4												
Actual	1980		79	46	72	138	NC	NC	23.6	13.7	21.5	41.2
20-pace	1980		84	43	71	132	NC	NC	25.5	13.0	21.5	40.0
Random	1980		77	91	88	68	15	28	23.8	28.1	27.2	21.0
Total (section 1-4)												
Actual	1980		324	171	176	300	NC	NC	33.4	17.6	18.1	30.9
20-pace	1980		340	177	155	334	NC	NC	33.8	17.6	15.4	33.2
Random	1980		333	239	160	274	301	54	33.1	23.8	15.9	27.2

Table 3. Continued.

Creek Section Method	Year	Number						Percentage ⁴			
		Pool	Riffle	Run	Pocket water	Back water	Side channel	Pool	Riffle	Run	Pocket water
Twentymile Creek											
Section 1 ⁶											
Actual	1980	236	24	110	191	NC	NC	42.1	4.3	19.6	34.0
20-pace	1980	268	7	81	147	NC	NC	53.3	1.4	16.1	29.2
Random	1980	315	65	54	217	281	66	48.4	10.0	8.3	33.3
Section 2											
Actual	1980	104	48	94	1	NC	NC	42.1	19.4	38.1	0.4
20-pace	1980	53	39	91	0	NC	NC	29.0	21.3	49.7	0
Random	1980	50	32	101	0	64	30	27.3	17.5	55.2	0
Section 3											
Actual	1980	176	34	112	221	NC	NC	32.4	6.3	20.6	40.7
20-pace	1980	257	27	156	260	NC	NC	36.7	3.9	22.3	37.1
Random	1980	298	40	203	165	117	110	42.2	5.7	28.8	23.4
Total (section 1-3)											
Actual	1980	516	106	316	413	NC	NC	38.2	7.8	23.4	30.6
20-pace	1980	578	73	328	407	NC	NC	41.7	5.3	23.7	29.4
Random	1980	663	137	358	382	462	206	43.1	8.9	23.2	24.8
West Fork of Twentymile Creek											
Section 4											
Actual	1980	177	124	68	32	NC	NC	44.1	30.9	17.0	8.0
20-pace	1980	151	104	76	22	NC	NC	42.8	29.5	21.5	6.2
Random	1980	160	92	80	22	137	0	45.2	45.2	26.0	6.2

¹ Actual counts of the number of habitat types.

² A count of habitat types every 20-paces.

³ A random count of habitat types.

⁴ Backwaters and side channels are not included in percentage.

⁵ No Count (NC).

⁶ Does not include the numerous waterfalls and cascades located in section.

Table 4. Results from pairwise comparisons for numbers and percentages of habitat types between actual counts, 20-pace and random sample methods done on Gospel-Hump area streams.

Habitat type	Actual count versus		20-pace versus	
	20-pace	Random	Random	Hoteling
Numbers				
Pools	.783	.628	.489	.802
Riffles	.259	.739	.143	.375
Runs	.640	.563	.104	.206
Pocketwaters	.828	.256	.229	.451
Percentages				
Pools	1.000	.558	.257	.221
Riffles	.459	.384	.778	.704
Runs	.625	.788	.421	.732
Pocketwaters	.537	.436	.557	.757

stretches of continuous habitat types may have been counted as one type because of scalar differences in the photographs.

In section 2 of Twentymile Creek one pool in the random pace survey was 54.0 m long. The length of this pool inflated the estimated average pool length resulting in a lower computed number of pools. This would explain the difference between the actual number of pools (104) and the number calculated by the random pace survey (50) (Table 3).

We believe the random pace method predicts the percentage of each habitat type within reasonable limits, but does not provide reliable estimates of the number of each habitat type.

In Tenmile and Twentymile Creeks the wetted surface area of each habitat type was estimated by multiplying the mean area of each habitat type by the actual number of that habitat type. This method was believed to be the most accurate. In Johns Creek an alternate method was used to estimate wetted surface area. The percent of each habitat type from the random pace survey, expressed as a decimal, was multiplied by the length of the stream section and then multiplied by the average width of the habitat type. Total surface area of each stream section was calculated by summing the calculated areas of all habitat types within each section. Actual area measured and snorkled was between 4 and 11 percent of the estimated total surface area (Table 5).

In Johns Creek pocketwaters and pools were the most abundant habitat types comprising 33.8 and 26.8% of the total

Table 5. Estimated wetted surface area (m²) and actual area measured (percentages in parentheses) in Johns, Tenmile and Twentymile Creeks, 1979, 1980 and 1981.

Estimated wetted surface area (m ²)								
Creek Section	Pools	Riffles	Runs	Pocket waters	Back waters	Side channels	Total	Actual area measured
Johns								
Section 1	42,775 (28.2)	33,608 (22.2)	7,575 (5.0)	61,197 (40.4)	2,549 (1.7)	3,734 (2.5)	151,438	6,054 (4.0)
Tenmile								
Section 1	11,125 (45.5)	3,900 (16.0)	1,919 (7.9)	5,740 (23.5)	1,531 (6.3)	223 (0.9)	24,438	2,321 (9.5)
Section 2	3,218 (65.4)	439 (8.9)	0 (-)	1,260 (25.6)	0 (-)	0 (-)	4,917	606 (12.3)
Section 3	6,055 (24.5)	7,198 (29.1)	3,841 (15.5)	7,030 (28.4)	323 (1.3)	293 (1.2)	24,740	2,911 (11.8)
Section 4	5,451 (17.6)	4,996 (16.1)	4,730 (15.2)	14,090 (45.4)	612 (2.0)	1,151 (3.7)	31,030	3,557 (11.5)
Total	25,849 (30.4)	16,533 (19.4)	10,490 (12.3)	28,120 (33.0)	2,466 (2.9)	1,667 (2.0)	85,125	9,395 (11.0)
Twentymile								
Section 1	7,717 (32.3)	967 (4.0)	3,487 (14.6)	10,104 (42.3)	1,265 (5.3)	363 (1.5)	23,903	729 (3.0)
Section 2	11,970 (50.9)	3,326 (14.1)	6,956 (29.6)	0 (-)	493 (2.1)	768 (3.3)	23,513	2,469 (10.5)
Section 3	7,973 (30.0)	1,476 (5.6)	3,483 (13.1)	11,404 (42.9)	562 (2.1)	1,661 (6.3)	26,559	1,167 (4.4)
Total	27,660 (37.4)	5,769 (7.8)	13,926 (18.8)	21,508 (29.1)	2,320 (3.1)	2,792 (3.8)	73,975	4,365 (5.9)

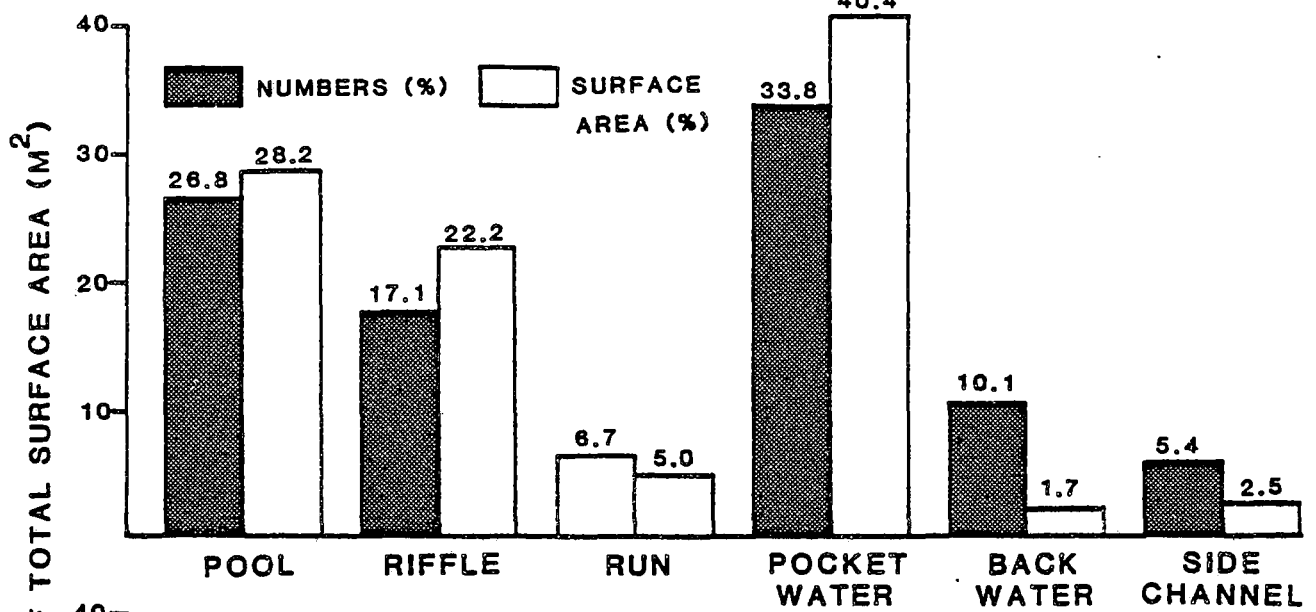
number, respectively (Figure 4). In Tenmile and Twentymile Creeks pools and backwaters were most abundant habitat types comprising 24.5 and 22.1% and 30.0 and 20.9% of the total number (Figure 4). However, pocketwaters covered more surface area than backwaters comprising 33.0 and 29.0% in Tenmile and Twentymile Creeks, respectively (Figure 4). In Johns and Tenmile Creek pocketwater habitats were most abundant in terms of surface area. In Twentymile Creek pools were most abundant.

Quality of Habitat

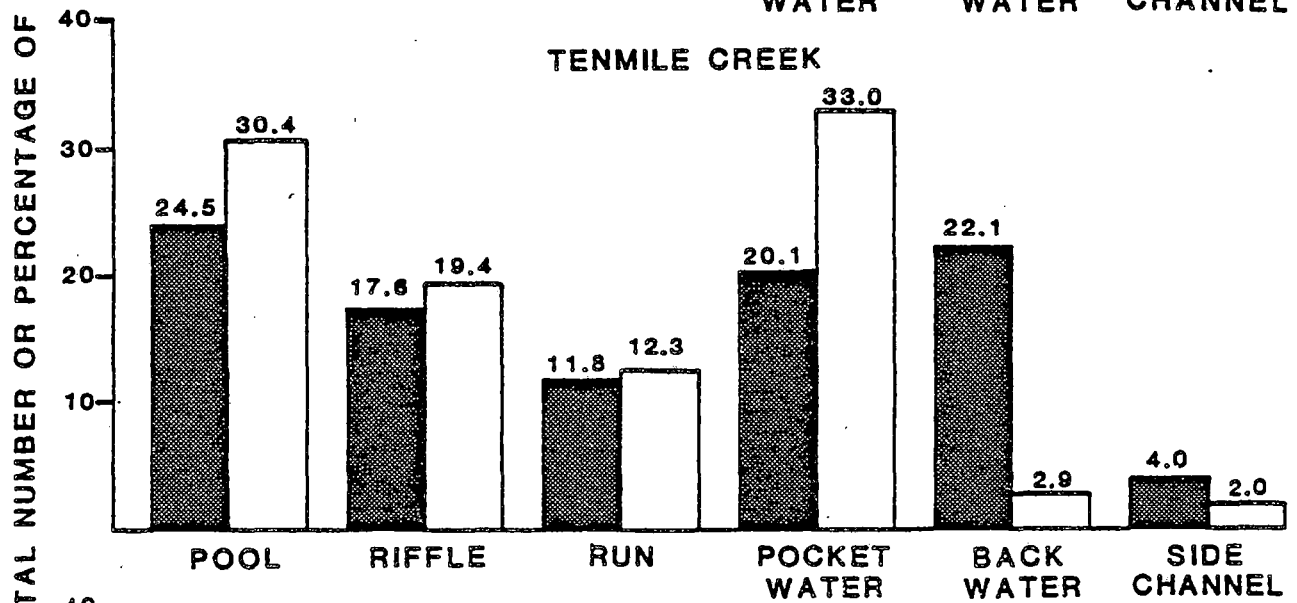
Mean values for all physical measurements of habitat parameters and the percentages of each substrate size class, instream cover class, and bank cover type are presented in Appendix A (Tables A-1 and A-2).

Undercut banks are almost totally absent from all stream sections surveyed with the exception of section 3 of Trapper Creek. The cause of this paucity of undercut banks is due to the annual stream flow fluctuations. During July and August the stream flows have diminished so that undercut banks created during high spring flows are unavailable as cover since the wetted stream width does not extend from bank to bank. The bank cover type "overhang less than 2 m" accounted for the majority of the bank cover. Bank cover was very sparse in Johns Creek due to the narrow valley bottom and stream flow fluctuations inhibiting riparian zone development.

Logs, boulders or debries in the water dominated the



TENMILE CREEK



TWENTYMILE CREEK

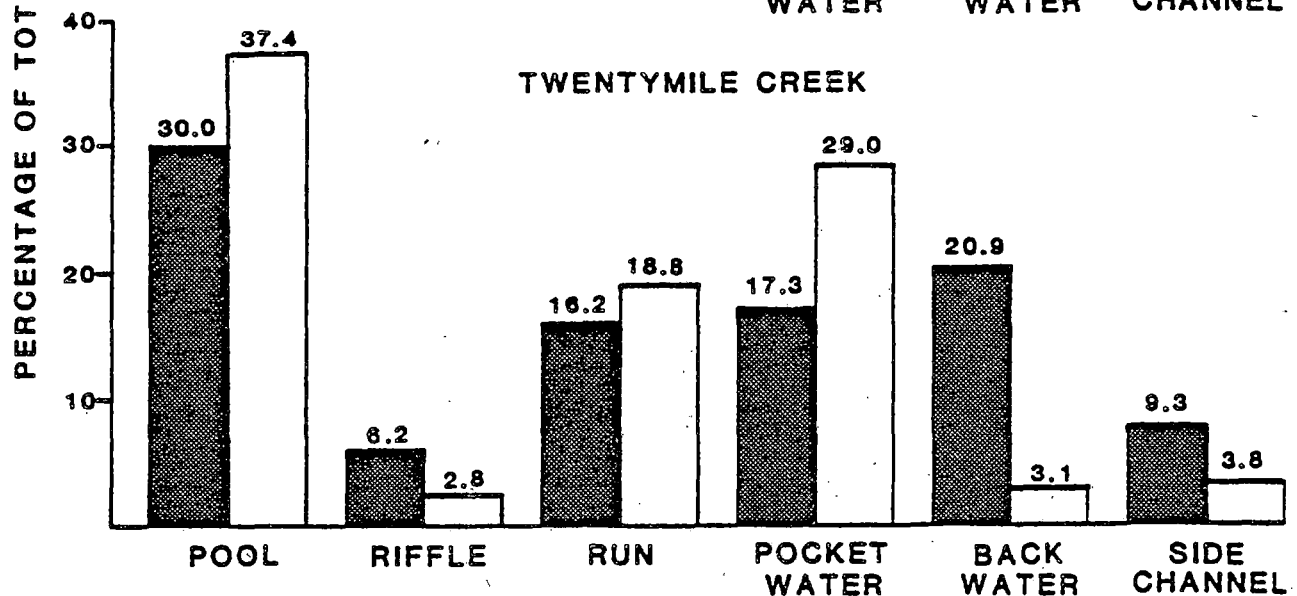


Figure 4. Percentage total number and percentage total surface area (m^2) for each habitat types in Johns, Tenmile and Twentymile Creeks, 1979-1980.

instream cover in almost all areas where instream cover was present. Aquatic vegetation was only found in the two meadow type stream sections, section 3 of Trapper Creek and section 2 of Twentymile Creek.

Pools containe higher percentages of the smaller sized particles (sand and silt). Streambed composition was closely related to stream gradient. More sand, pea gravel and gravel was present in the low gradient meadow areas, section 3 of Tenmile Creek, the West Fork of Twentymile Creek, section 3 of Trapper Creek, section 2 of Twentymile Creek, and the West Fork of Red River section (Figures 5-8).

Suitable spawning substrate was defined as riffle areas which contained more that 25 percent gravel and pea gravel and less than 20 percent sand and silt. When identifying stream sections that provided important spawning habitat for salmonids, we selected sections of stream which contained more than fifty percent riffle and pocketwater habitat types combined. The substrate composition of the riffles and pocketwaters were similiar in the areas of proper water depth for spawning. In the MRDA, sections 3 and 4 of Tenmile Creek and section 2 of Twenymile Creek met the criteria. We believe section 2 of Twenytmile Creek provides important spawning habitat for the stream, but the substrate contains a high percentage of sand (Figure 6). The lower two km of the West Fork of Twentymile Creek also contains excellent spawning habitat. Johns Creek does not have large continuous areas of

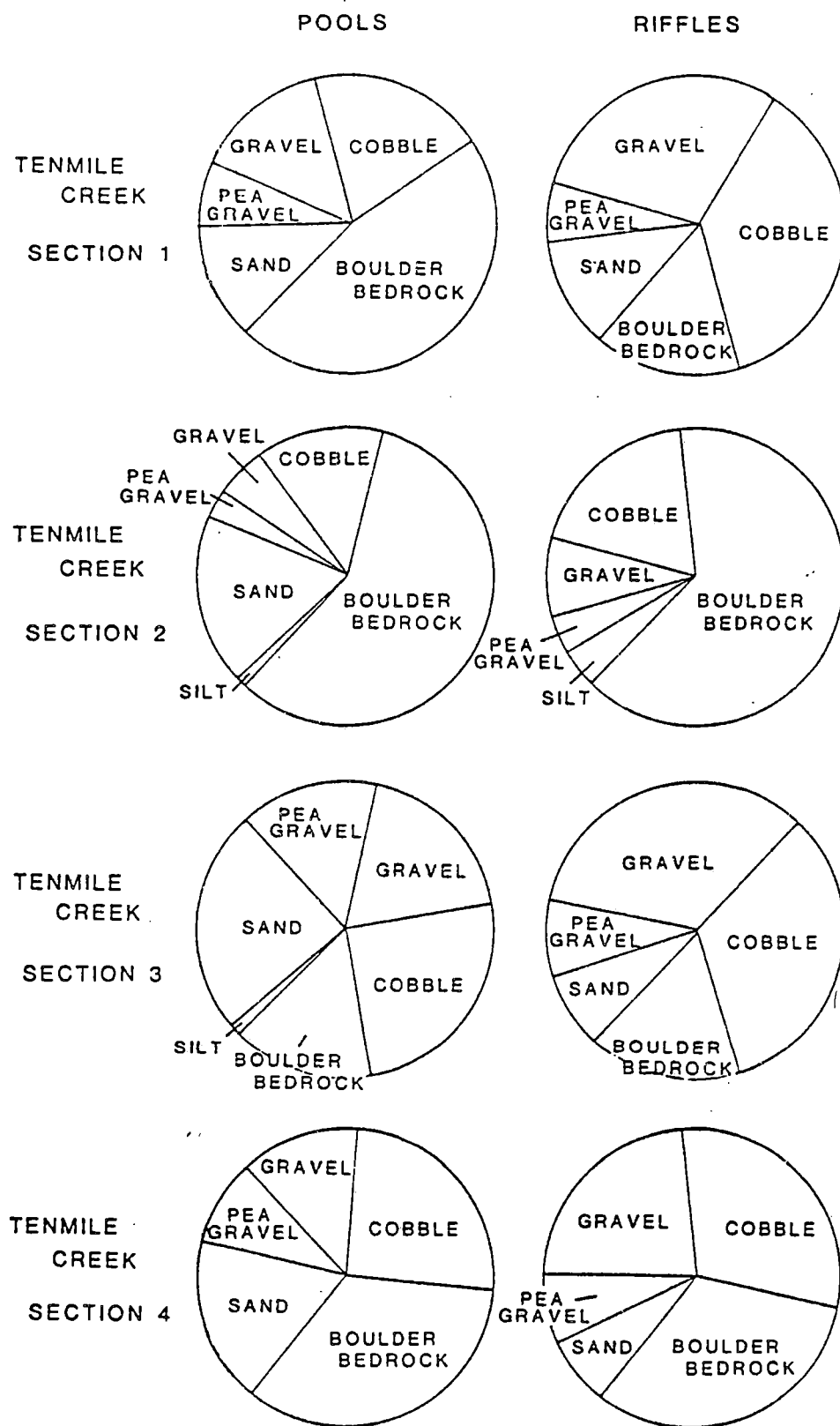


Figure 5. Substrate composition of pools and riffles for the four sections of Tenmile Creek.

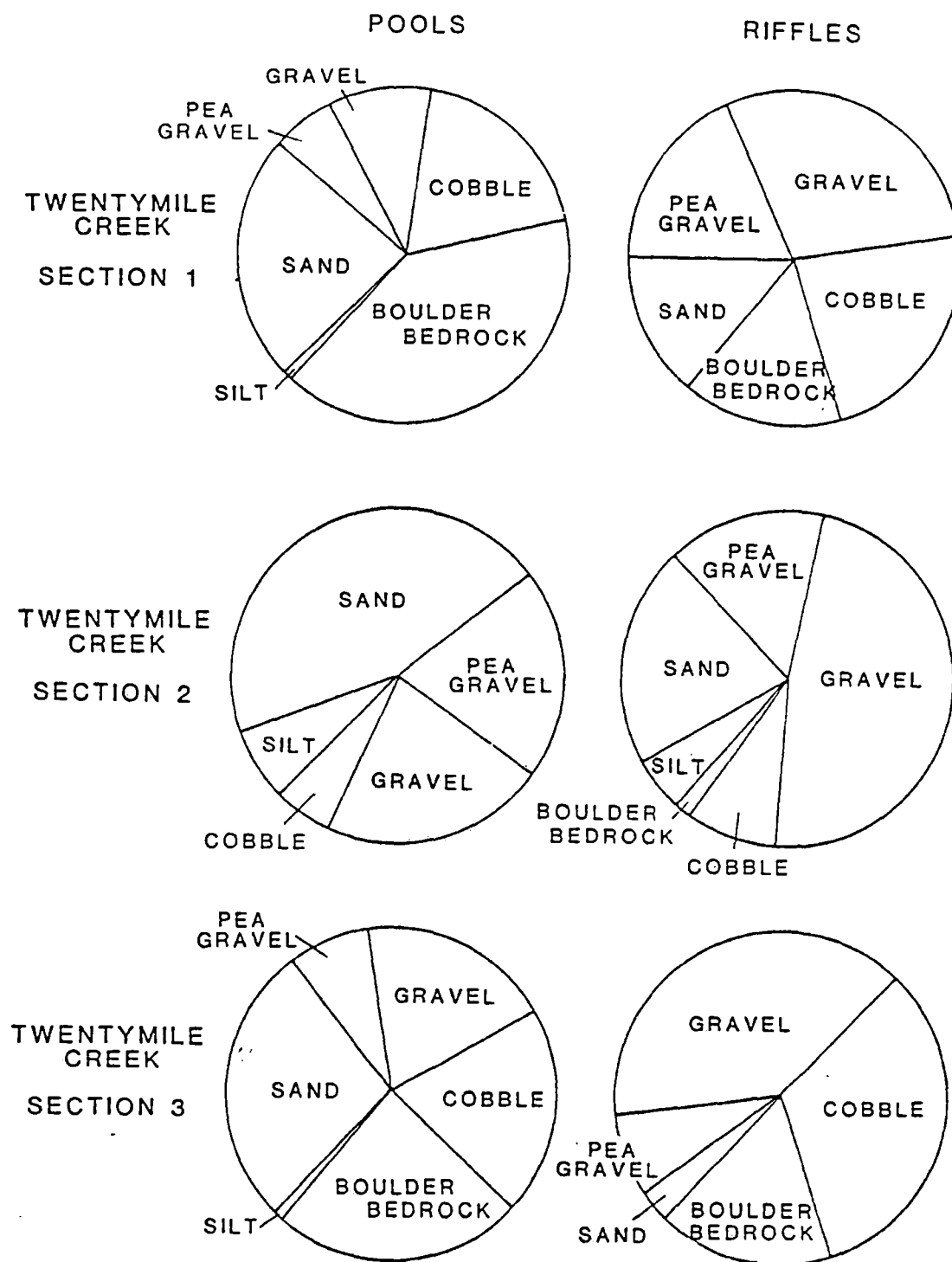


Figure 6. Substrate composition of pools and riffles for the three sections of Twentymile Creek.

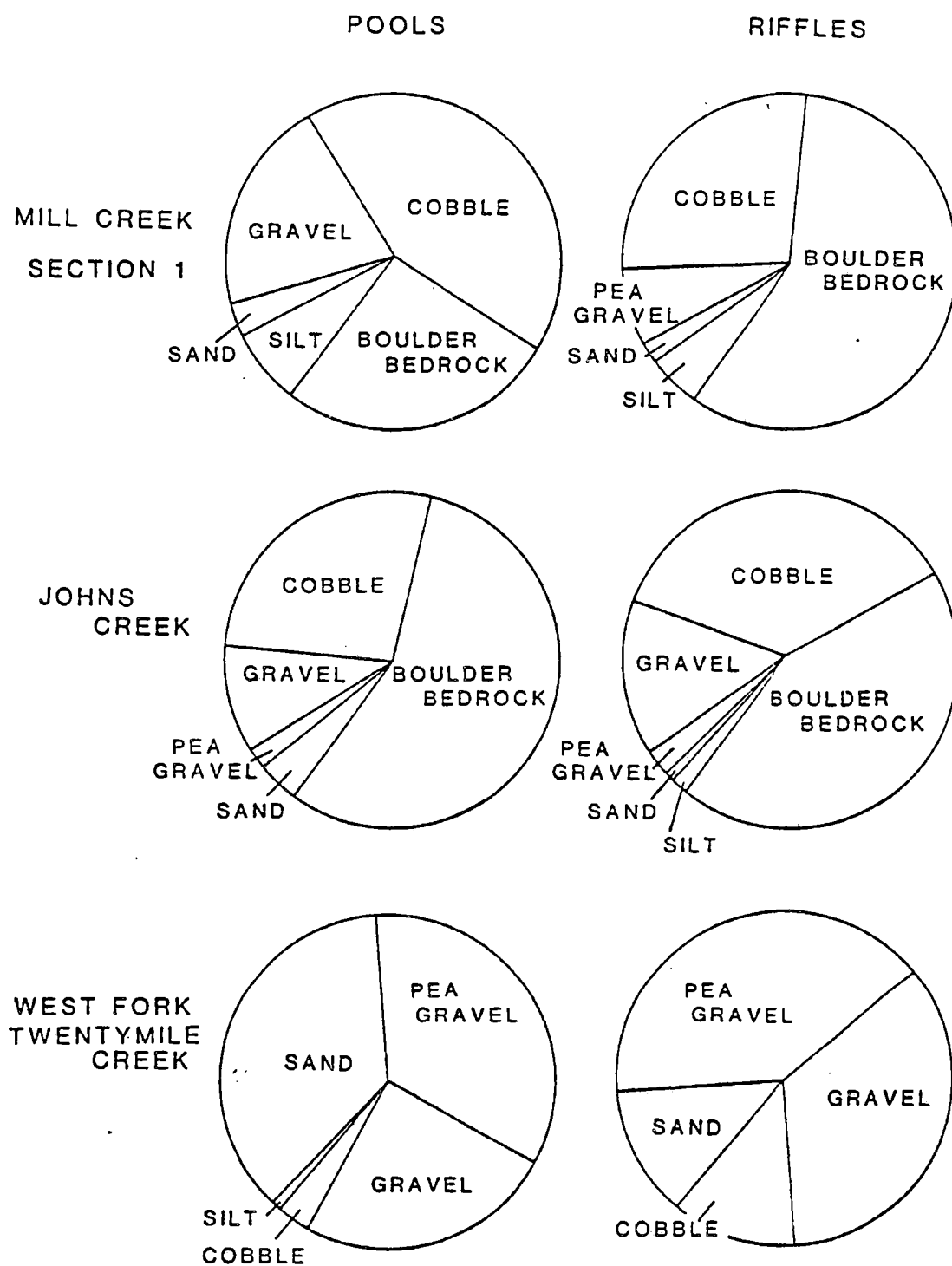


Figure 7. Substrate composition of pools and riffles in Mill, Johns and the West Fork of Twentymile creeks.

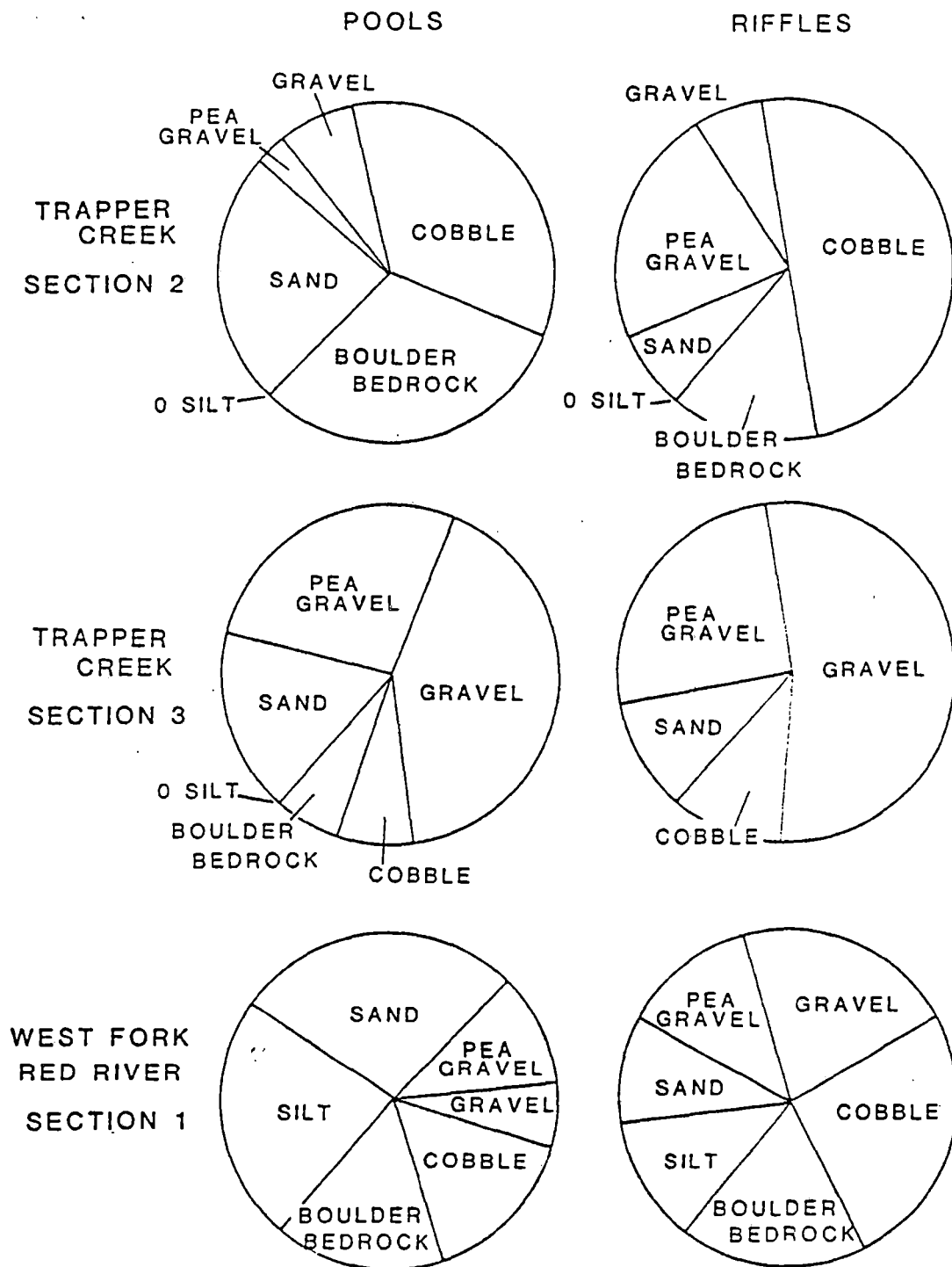


Figure 8. Substrate composition of pools and riffles for sections 2 and 3 of Trapper Creek and section 1 of the West Fork of Red River.

spawning gravel, but does contain isolated "patches" of suitable spawning substrate.

The spawning habitat in Trapper Creek, Mill Creek and the West Fork of Red River was evaluated for the sections surveyed and based solely on the substrate composition of the riffles. Section 2 and 3 in Trapper and the single study section in the West Fork of Red River contained high percentages of gravels suitable for spawning. Riffles in section 3 of Trapper Creek were comprised of nearly eighty percent gravels, identifying this section as very important for spawning. Riffle areas of Mill Creek had very little gravel suggesting that the study section in Mill Creek is not an important spawning area. However, the highest density of 0-50 mm trout were observed in this section. I speculated that these fry were produced upstream for the study section and dispersed downstream after emerging to rear.

Fish Abundance

Species Composition

The following fish species were present in the study area: rainbow/steelhead trout (Salmo gairdneri), westslope cutthroat trout (Salmo clarki), bull trout (Salvelinus confluentus), mountain whitefish (Prosopium williamsoni), chinook salmon (Oncorhynchus tshawytscha), sculpin (Cottus sp.), and longnose dace (Rhinichthys cataractae).

Several interesting species of amphibians were observed in

the study area including tailed frogs (Ascaphus truei) and Pacific giant salamanders (Dicamptodon ensatus). The major orders of aquatic macroinvertebrates (Ephemeroptera, Plecoptera, Trichoptera, and Diptera) were also observed.

Steelhead trout and chinook salmon fry were released into several tributaries to the South Fork of the Clearwater River by the Idaho Department of Fish and Game as part of their reintroduction of anadromous stocks program. Rainbow and cutthroat trout populations are the major fish species present in the study area. Anadromous species, chinook salmon and steelhead trout populations were important in the past but have dwindled to remnant status.

Johns Creek: Rainbow/steelhead were the most abundant species observed in Johns Creek, comprising 94.5 and 96.2 percent of the fish seen during 1979 and 1981, respectively (Figure 9 and Appendix B). Cutthroat and bull trout were observed in the creek above the falls (9.7 km above the mouth), while mountain whitefish, chinook salmon and longnose dace were also present below the falls. It appeared the falls effectively blocked whitefish and longnose dace from entering the upper portion of the drainage. One adult chinook salmon was observed during our studies in the wilderness portion of Johns Creek in August of 1980. Chinook salmon (age 0 and I) comprised 1.5 percent of the fish observed in 1979, but were not observed in 1980 or 1981.

Rainbow/steelhead made up more than 75 percent of the fish

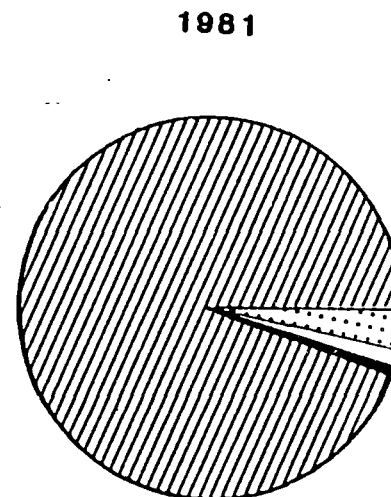
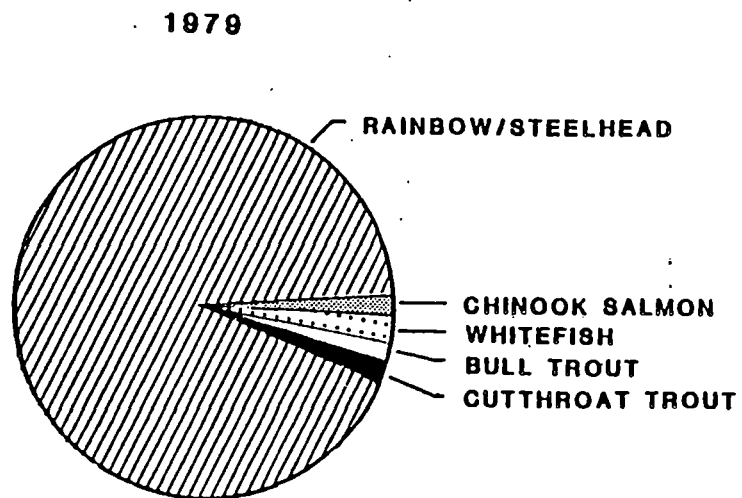


Figure 9. Species composition in Johns Creek.

caught by angling in Johns Creek in the Gospel-Hump Wilderness Area. Cutthroat trout and fish which appeared to be rainbow-cutthroat hybrids from external morphologic characters were also captured. It is probable bull trout were present but not caught by angling.

Tenmile Creek: Rainbow/steelhead and chinook salmon were the most abundant species observed in Tenmile Creek, comprising more than 90 percent of the fish observed in sections 1-3 and 80.0 percent in section 4 (Figure 10 and Appendix B). In 1979 age 0 chinook salmon were most abundant (88.3%) downstream from the Sourdough Road bridge (section 3), while very few (7.1%) chinook fry were observed upstream from the bridge (Figure 10). Wild chinook fry (less than 40 mm) were observed below the bridge in 1979 in addition to chinook fingerlings (40-70 mm) released for this study. No age 0 chinook were seen in 1981. An adult female chinook salmon was seen in section 2 on July 29, 1979. Cutthroat trout were relatively more abundant in snorkel transects upstream of the Sourdough Road bridge (section 4) than below (Figure 10). Mountain whitefish and bull trout were present in limited numbers throughout the drainage.

In the Gospel-Hump Wilderness Area cutthroat made up 80 percent of the fish captured via angling in Tenmile Creek. Rainbow/steelhead were second in abundance.

Twentymile Creek: Cutthroat and rainbow trout were the only species present in Twentymile Creek. Impassible falls and

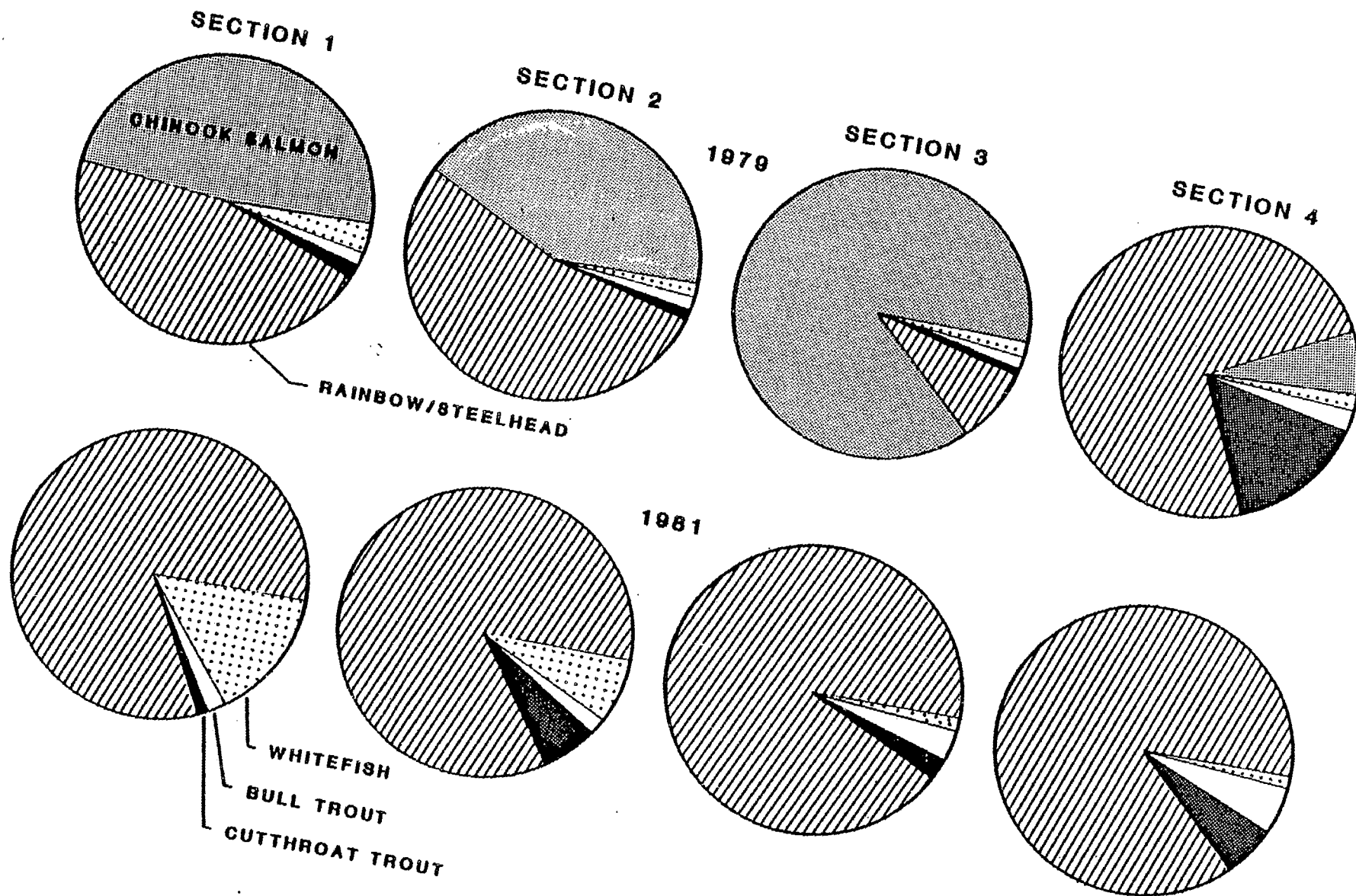


Figure 10. Species composition in four sections of Tenmile Creek.

cascades near the mouth have probably acted as barriers to other fish species. Cutthroat trout comprised more than 80 percent of the fish during 1980 (Figure 11 and Appendix B). Rainbow trout were relatively more abundant (29.6%) in section 2 during 1981. In 1981, cutthroat trout comprised 100 and 99.3 percent of the fish in sections 2 and 3, respectively (Figure 11). Cutthroat-rainbow hybrids were seen in transects and captured by angling, especially in section 2.

Mill Creek: Rainbow/steelhead trout were the most abundant species observed in Mill Creek, comprising 100 and 98.8 percent of the fish counted in 1979 and 1980, respectively (Figure 12 and Appendix B). Cutthroat trout were present in limited numbers (1.2%) in 1980.

West Fork of Red River: In 1979, cutthroat trout were the most abundant species in the West Fork of Red River, comprising more than 73.7 percent of the fish observed (Figure 13 and Appendix B). In 1981, rainbow trout replaced cutthroat trout as the most abundant fish comprising 52.0 percent. Bull trout and whitefish were also present.

Trapper Creek: Cutthroat trout were the most abundant fish observed in Trapper Creek during 1979, 1980 and 1981 (Figure 14 and Appendix B). In 1981, only cutthroat trout were observed (Figure 14). Rainbow/steelhead, Eastern brook and bull trout were present in limited numbers.

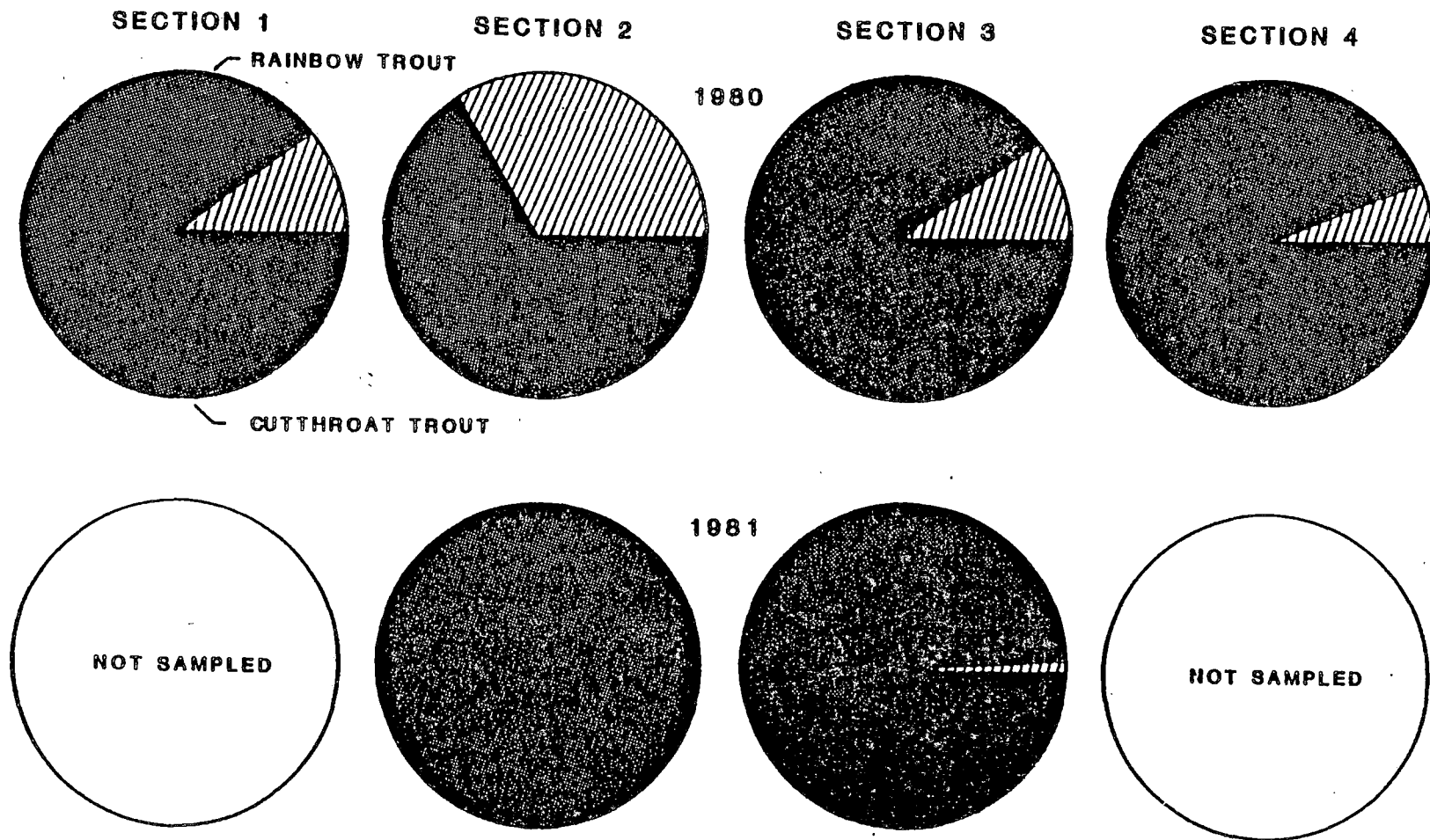


Figure 11. Species composition in Twentymile (Sections 1-3) and West Fork of Twentymile (Section 4) Creeks.

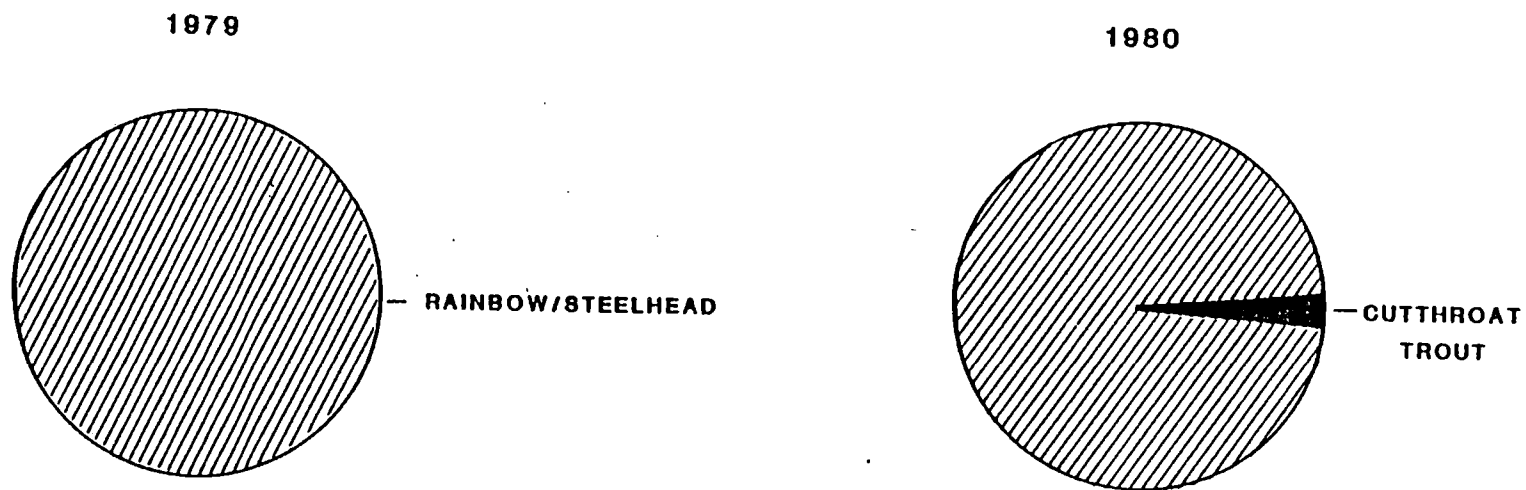


Figure 12. Species composition in study section of Mill Creek.

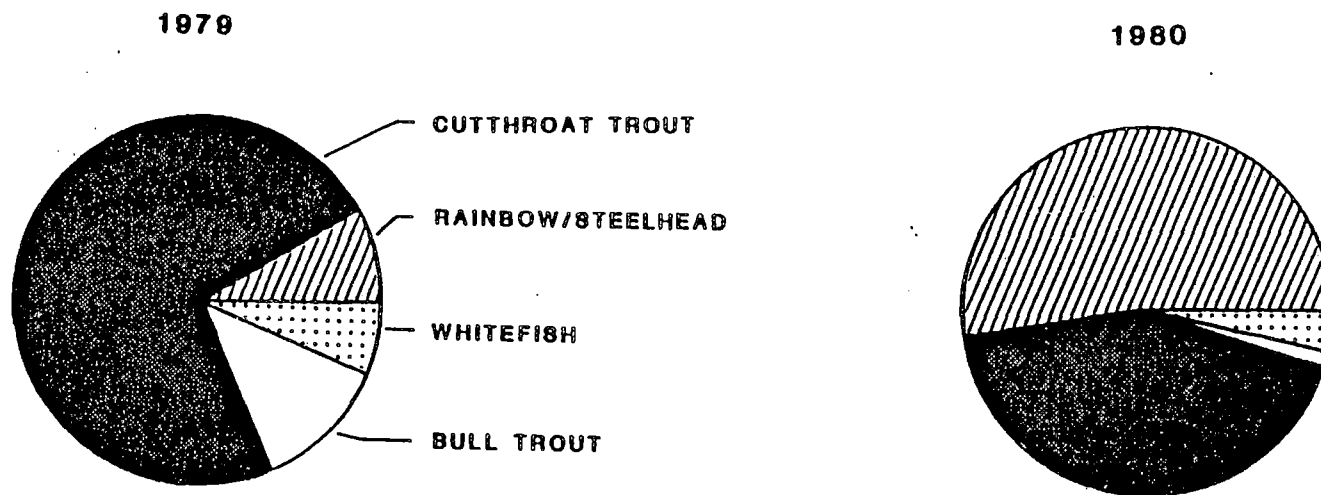


Figure 13. Species composition in study section of West Fork Red River.

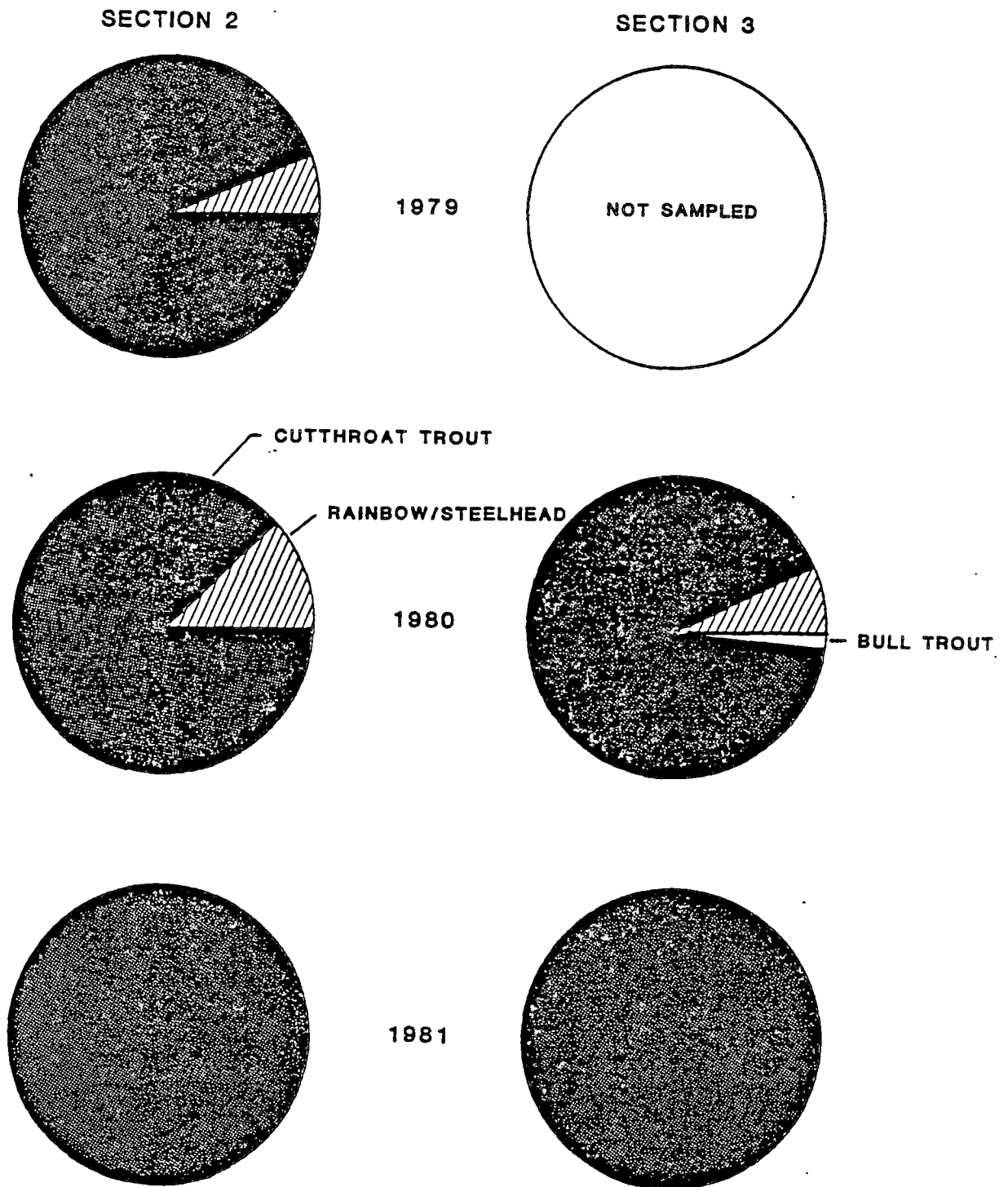


Figure 14. Species composition in two sections of Trapper Creek.

Fish Densities

Fish densities in the Gospel-Hump area study streams ranged from 0.1 to 72.8 trout fry (up to 50 mm in length), 0.4 to 52.6 trout 51 to 150 mm and 0.05 to 8.4 trout longer than 150 mm per 100 m² (Appendix C). Whitefish densities ranged from 0.2 to 1.4 fish 51 to 150mm and 0.1 to 2.5 fish longer than 150 mm. No whitefish fry (0 to 50 mm) were observed (Appendix C). Chinook salmon densities ranged from 0.4 to 386.7 age 0 fish and 0.03 to 3.7 age I fish per 100 m² (Appendix C).

Densities decreased in all study streams except Mill Creek between 1979 and 1981 (1980 for West Fork of Red River) (Figures 15, 16 and 17). The highest total average density was observed in Mill Creek (58.9 fish per 100 m²) followed by West Fork Red River (56.7), Tenmile Creek (43.2), Johns Creek (34.0), Twentymile Creek (18.9) and Trapper Creek (17.7) (Figures 15, 16 and 17).

Johns Creek: In Johns Creek the average total density decreased from 34.0 in 1979 to 12.4 fish per 100 m² in 1981 (Figure 15). A decrease in fry (0 to 50 mm) density from 24.7 fish per 100 m² to 2.1 in 1981 was responsible for the decrease in total fish density (Figure 15). The average density for fish 51 to 150 and longer than 150 mm in length increased between 1979 and 1981 (Figure 15). The high fry densities in 1979 was probably due to a release of 400,000 steelhead trout fry. No fry were released in 1980 or 1981.

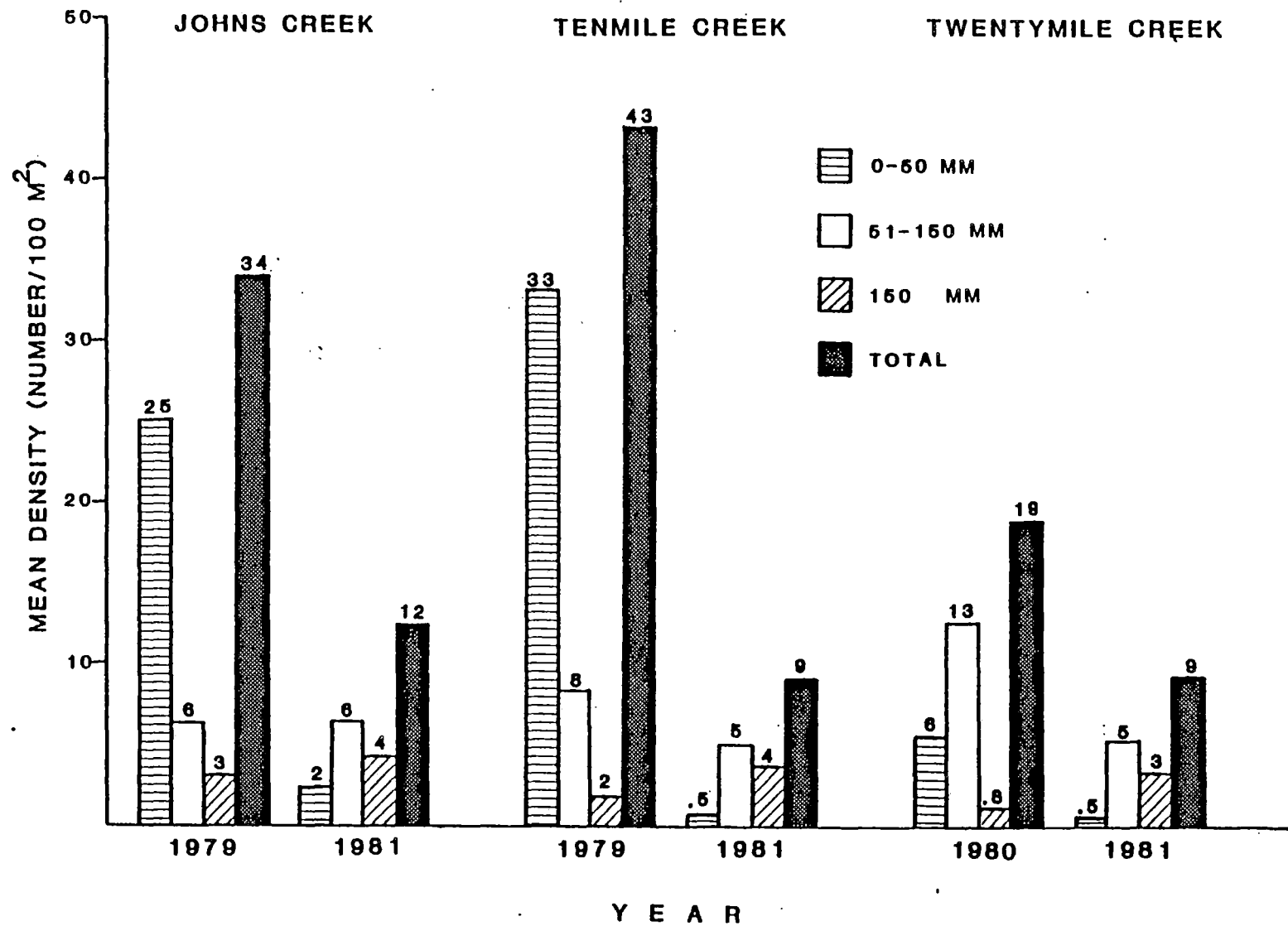


Figure 15. Average fish density (number/100m²) in Johns, Tenmile (Sections 1-4 combined) and Twentymile Creeks (Sections 2-3 combined).

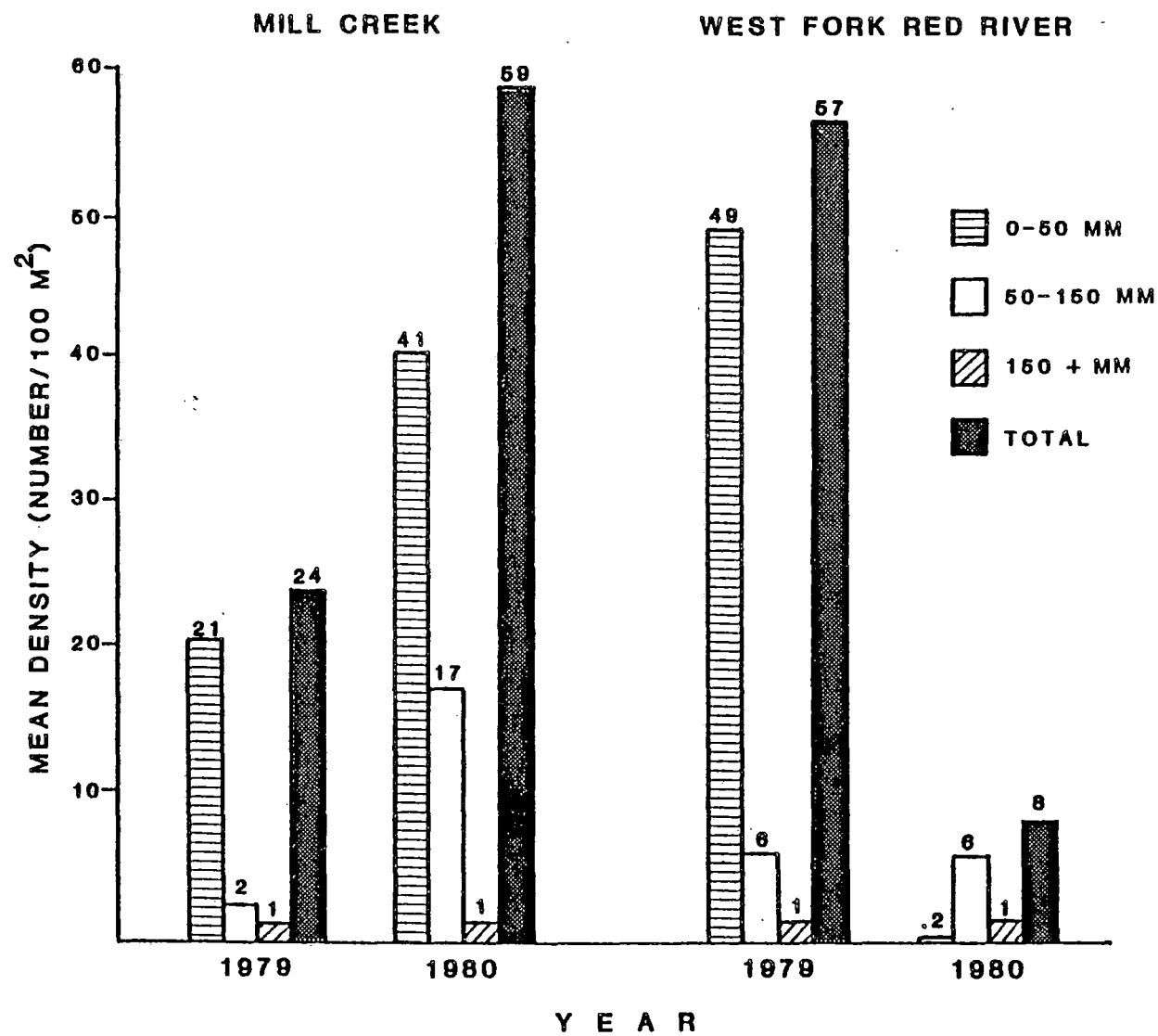


Figure 16. Average fish density (number per 100m²) in study sections of Mill Creek and West Fork Red River.

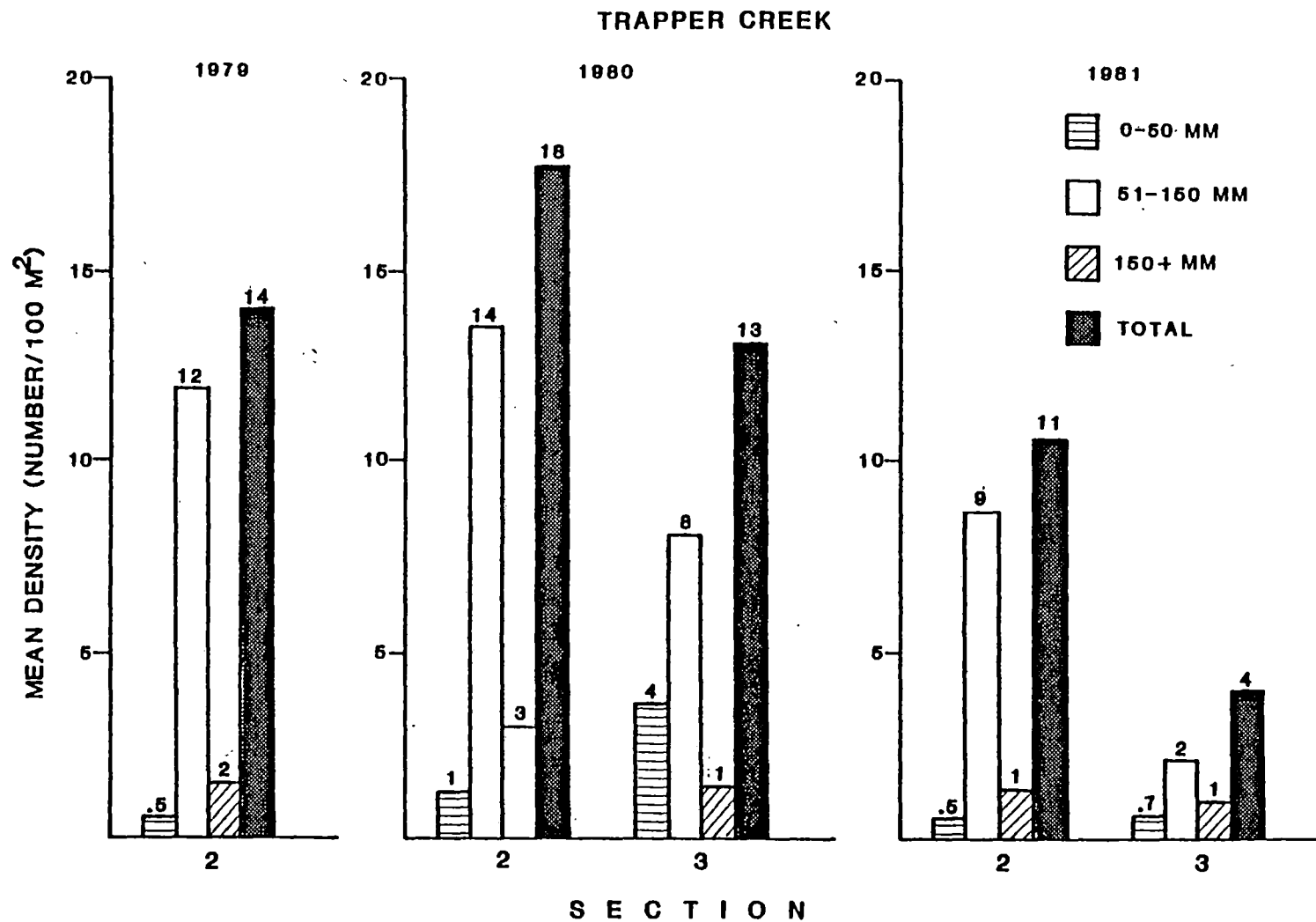


Figure 17. Average fish densities (number per 100m²) in Trapper Creek (Section 2-3 combined).

In 1979, densities for fish 0 to 50, 51 to 150 and longer than 150 mm ranged from 9.3 to 53.5, 2.4 to 9.2 and 0.8 to 7.4 per 100 m², respectively (Appendix C-1). In 1981, densities for fish 0 to 50, 51 to 150 and longer than 150 mm ranged from 0.9 to 3.6, 1.9 to 9.9 and 1.1 to 6.8, respectively (Appendix C-1).

Tenmile Creek: In sections 1, 3 and 4 of Tenmile Creek the average total density decreased from 46.7 to 10.0, 85.4 to 13.4 and 9.8 to 6.1 fish per 100 m² between 1979 and 1981, respectively (Figure 18). In section 2 total average densities increased from 6.9 to 13.4 fish per 100 m² (Figure 10). The high fry densities in 1979 are probably due to a release of 10,000 chinook salmon fry just below the Sourdough Road bridge (section 3). The average fry densities decreased in all sections between 1979 and 1981 (Figure 18). Generally, the average densities for fish 51 to 150 mm decreased between 1979 and 1981 and increased for fish longer than 150 mm (Figure 15). Exceptions were in sections 2 for fish 51 to 150 mm and section 4 for fish longer than 150 mm (Figure 18).

In 1979, densities for fish 0 to 50, 51 to 150 and longer than 150 mm in length ranged from 0.3 to 386.7, 3.8 to 15.3 and 0.5 to 5.0 per 100 m², respectively (Appendix C-2). The high density of 386.7 fish per 100 m² occurred in a backwater area of section 3 and were all age 0 chinook salmon. In 1981, densities for fish 0 to 50, 51 to 150 and longer than 150 mm in length ranged from 0.1 to 2.5, 3.5 to 8.9 and 0.2 to 9.0,

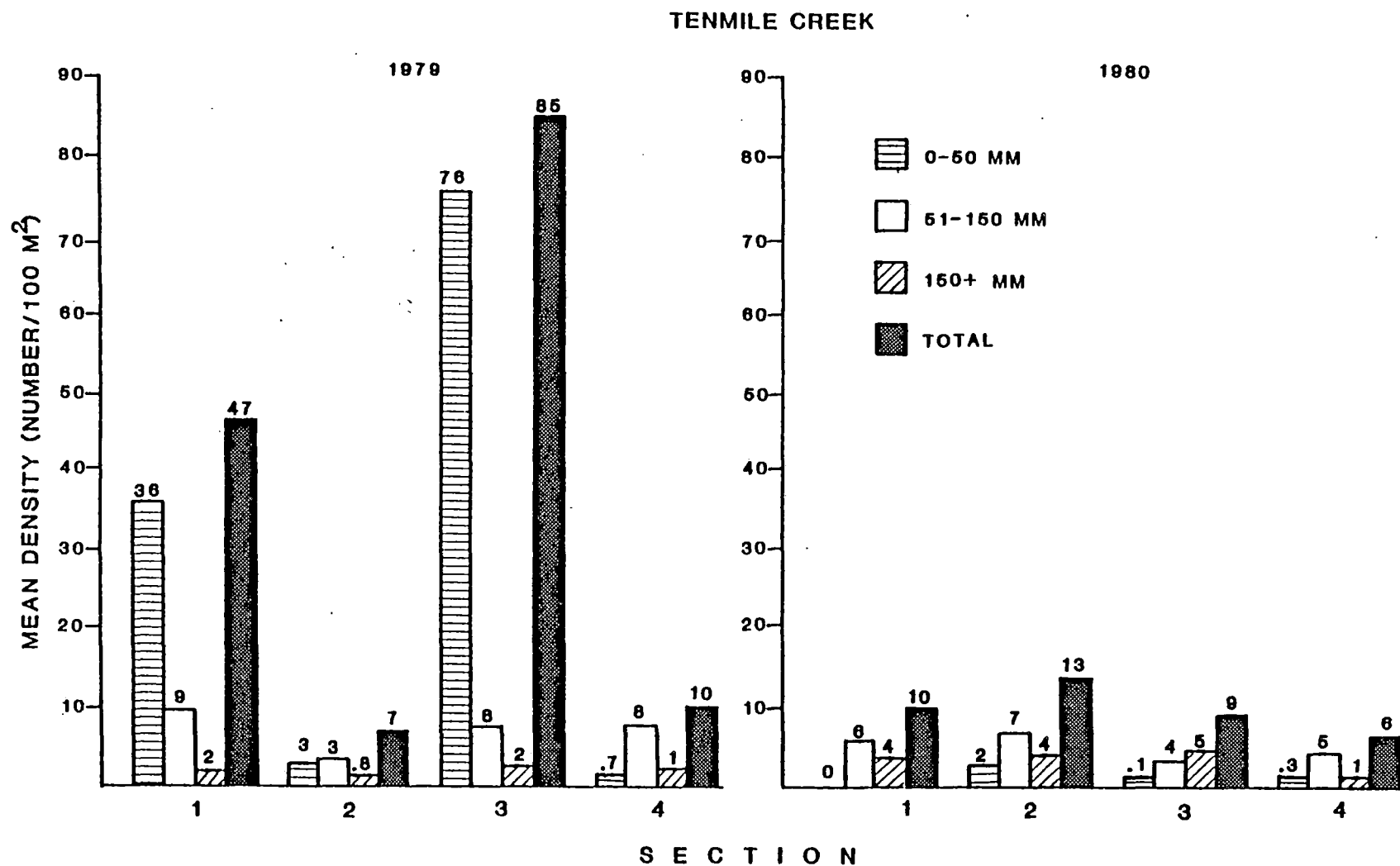


Figure 18. Average fish density (number per 100m²) in four sections of Tenmile Creek.

respectively (Appendix C-2).

Twentymile Creek: In sections 2 and 3 (the only two sections sampled both years) the average total density decreased from 8.3 to 2.0 and 27.6 to 14.7 fish per 100 m² between 1980 and 1981, respectively (Figure 19). The average fry densities decreased in both sections between 1980 and 1981 (Figure 14). The average density for fish 51 to 150 mm decreased while for fish longer than 150 mm in length densities increased between 1980 and 1981 (Figure 19).

In 1980 densities for fish 0 to 50, 51 to 150 and longer than 150 mm in length ranged from 0.9 to 31.6, 1.1 to 63.2 and 0.6 to 4.6 per 100 m², respectively (Appendix C-3). In 1981 densities for fish 0 to 50, 51 to 150 and longer than 150 mm in length ranged from 0.1 to 2.7, 0.7 to 11.6 and 0.4 to 8.4 per 100 m², respectively (Appendix C-3). The low densities in 1981 might reflect the late sampling date (September). The decrease in small fish (less than 150 mm in length) and increase in large fish (longer than 150 mm in length) would support this reasoning. Recruitment into larger size classes would be at its highest in early fall while smaller fish would be seeking refuge in the substrate.

Mill Creek: In Mill Creek the average total density increased from 24.1 to 58.9 fish per 100 m² between 1979 and 1980 (Figure 16). An increase in fry and fish 51 to 150 mm in length were mostly responsible for the increase in total density. The average density of fish 0 to 50, 51 to 150 and

TWENTYMILE CREEK

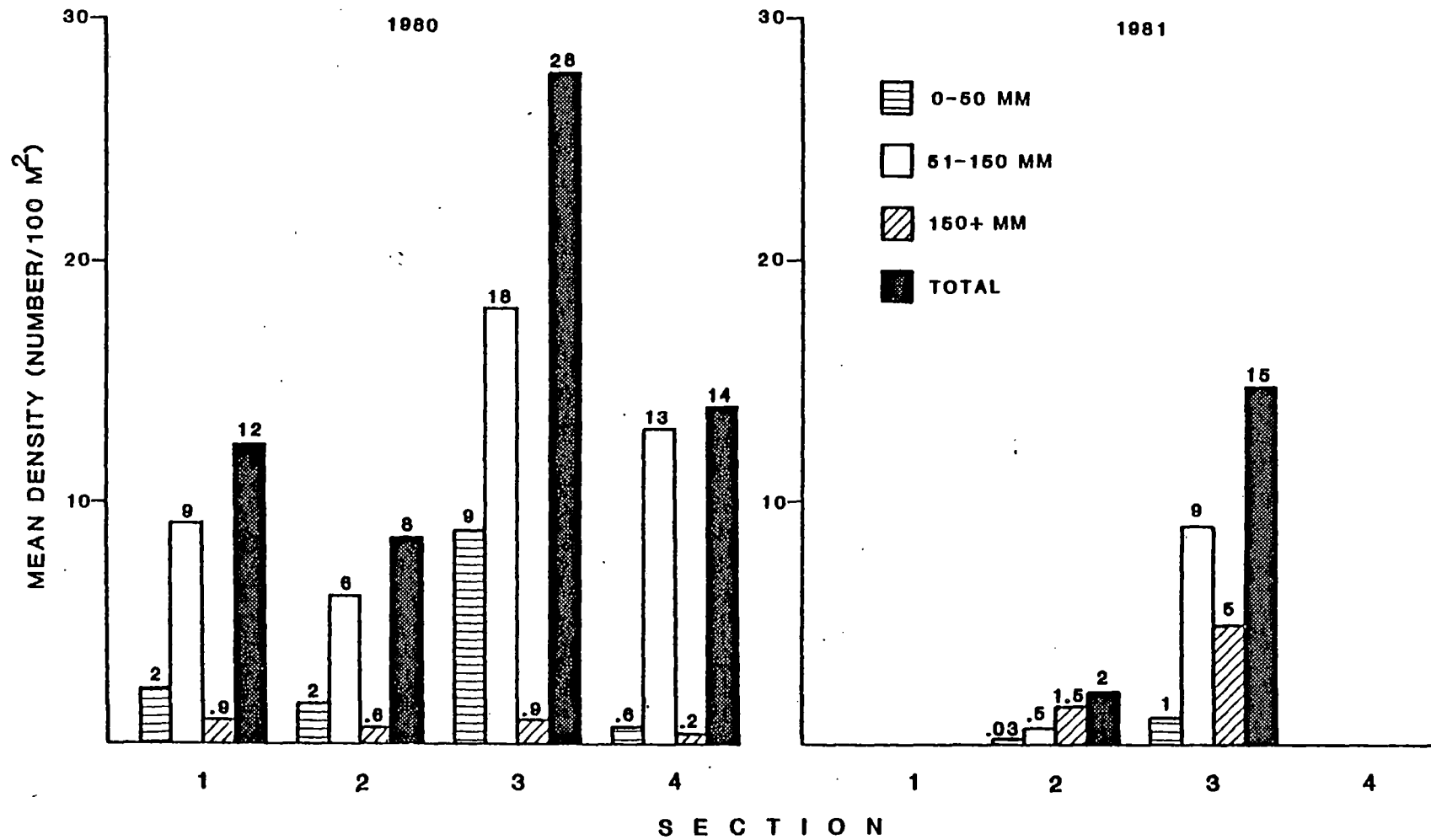


Figure 19. Average fish density (number per 100m²) in Twentymile (Sections 1-3) and West Fork of Twentymile (Section 4) Creeks.

longer than 150 mm in length increased from 20.7 to 40.6, 2.4 to 17.3 and 1.0 to 1.1 per 100 m² between 1979 and 1980, respectively (Figure 16).

In 1979 densities for fish 0 to 50, 51 to 150 and longer than 150 mm in length ranged from 16.5 to 25.6, 2.2 to 3.9 and 0.7 to 2.2 per 100 m², respectively (Appendix C-4). In 1980 densities for fish 0 to 50, 51 to 150 and longer than 150 mm in length ranged from 31.5 to 65.1, 6.3 to 23.0 and 0.8 to 2.2 per 100 m², respectively (Appendix C-4).

West Fork of Red River: In the West Fork Red River average total density decreased from 56.7 to 8.2 fish per 100 m² between 1979 and 1980 (Figure 16). A decrease in fry density from 49.0 to 0.2 fish per 100 m² was mostly responsible for the decrease in total density (Figure 16). The average densities for fish longer than 50 mm remained unchanged or nearly so (6.3 to 6.1 for 51 to 150 mm and 1.4 for 150+ mm) between 1979 and 1980 (Figure 16).

Densities for fish 0 to 50, 51 to 150 and longer than 150 mm in length ranged from 35.8 to 72.8, 3.9 to 9.9 and 0.4 to 4.1 in 1979 and 0 to 0.8, 1.3 to 8.8 and 0.8 to 3.0 per 100 m² in 1980, respectively (Appendix C-5).

Trapper Creek: In section 2 of Trapper Creek the average total density increased from 14.0 to 17.7 then decreased to 10.3 fish per 100 m² between 1979, 1980 and 1981 (Figure 17). Densities decreased from 13.1 to 3.9 fish per 100 m² in section 3 between 1980 and 1981 (Figure 17). The average total density

for fish 0 to 50, 51 to 150 and longer than 150 mm in length decreased between 1979 and 1980 from 1.2 to 0.5, 13.6 to 8.7 and 2.9 to 1.3 in section 2 and 3.6 to 0.7, 8.1 to 2.1 and 1.4 to 1.1 fish per 100 m² in section 3, respectively (Figure 17).

Fish Densities by Habitat Type

Fish densities in Gospel-Hump area study streams ranged from 0.1 to 42.4 fish 100 m² in pools, 0.3 to 32.8 in riffles, 0.2 to 65.1 in runs, 0.2 to 35.8 in pocketwaters, 0.7 to 386.7 in backwaters and 0.8 to 53.5 in side channels (Appendix C). The highest total fish density was observed in backwater areas followed by runs, riffles, side channels, pools and pocketwaters. Backwater and side channel habitat types were not sampled in Mill Creek, West Fork Red River and Trapper Creek or in Johns, Tenmile and Twentymile Creeks in 1981.

Johns Creek: In Johns Creek during 1979 densities were highest in side channels (63.0 fish per 100 m²) followed by backwaters (53.0), pools (29.0), runs (28.0), pocketwaters (19.0) and riffles (13.0) (Figure 20). In 1981, densities were highest in runs (18.0 fish per 100 m²), pools (16.0), pocketwaters (11.0) and riffles (5.0) (Figure 20).

Tenmile Creek: In Tenmile Creek during 1979 average total fish densities were highest in backwaters (175.0 fish per 100 m²) followed by pools (33.0), side channels (32.0), pocketwaters (16.0), runs (14.0) and riffles (12) (Figure 22). In 1981 fish densites were highest in pools (13.0 fish per 100

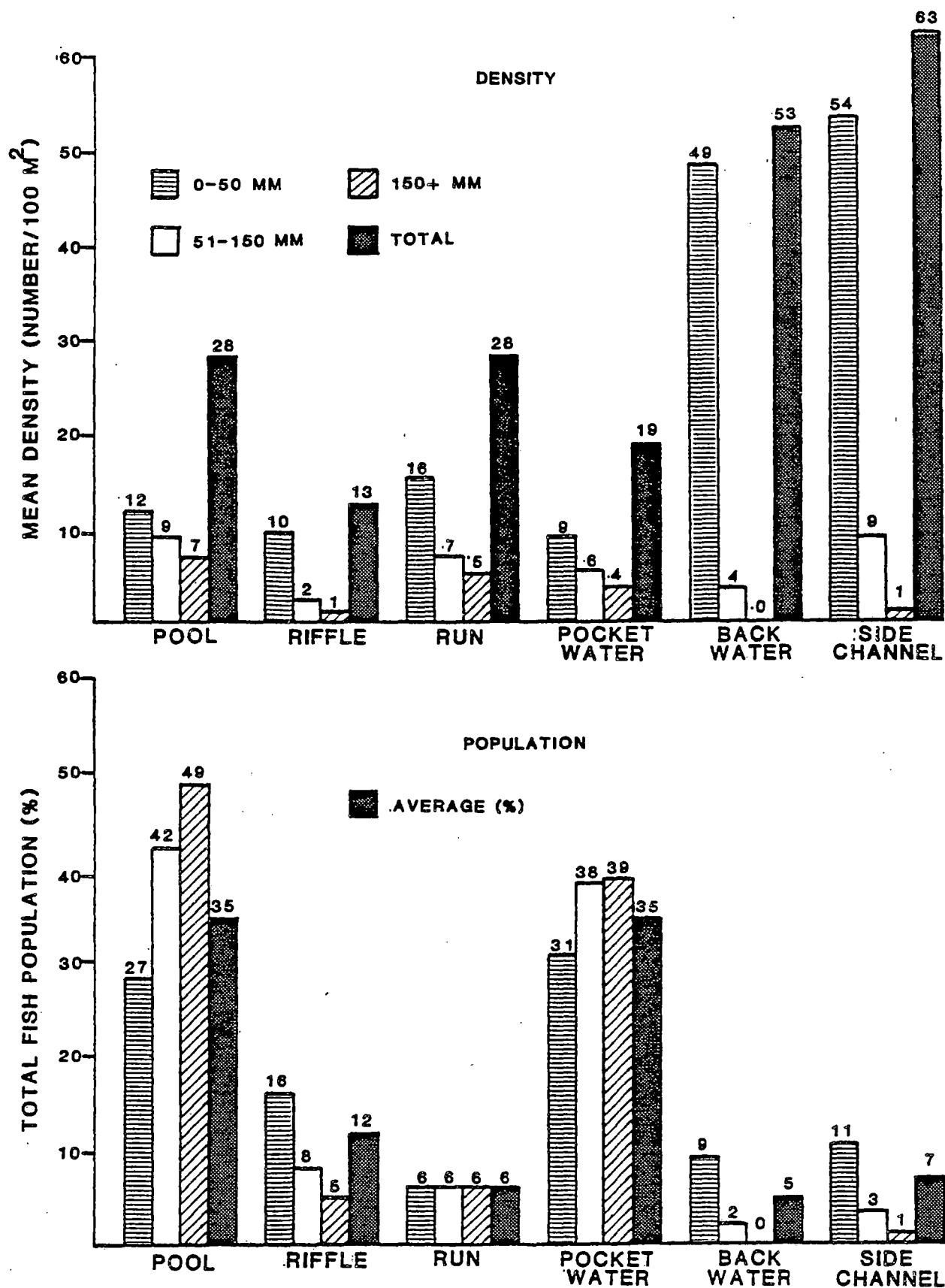


Figure 20. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in John's Creek, 1979.

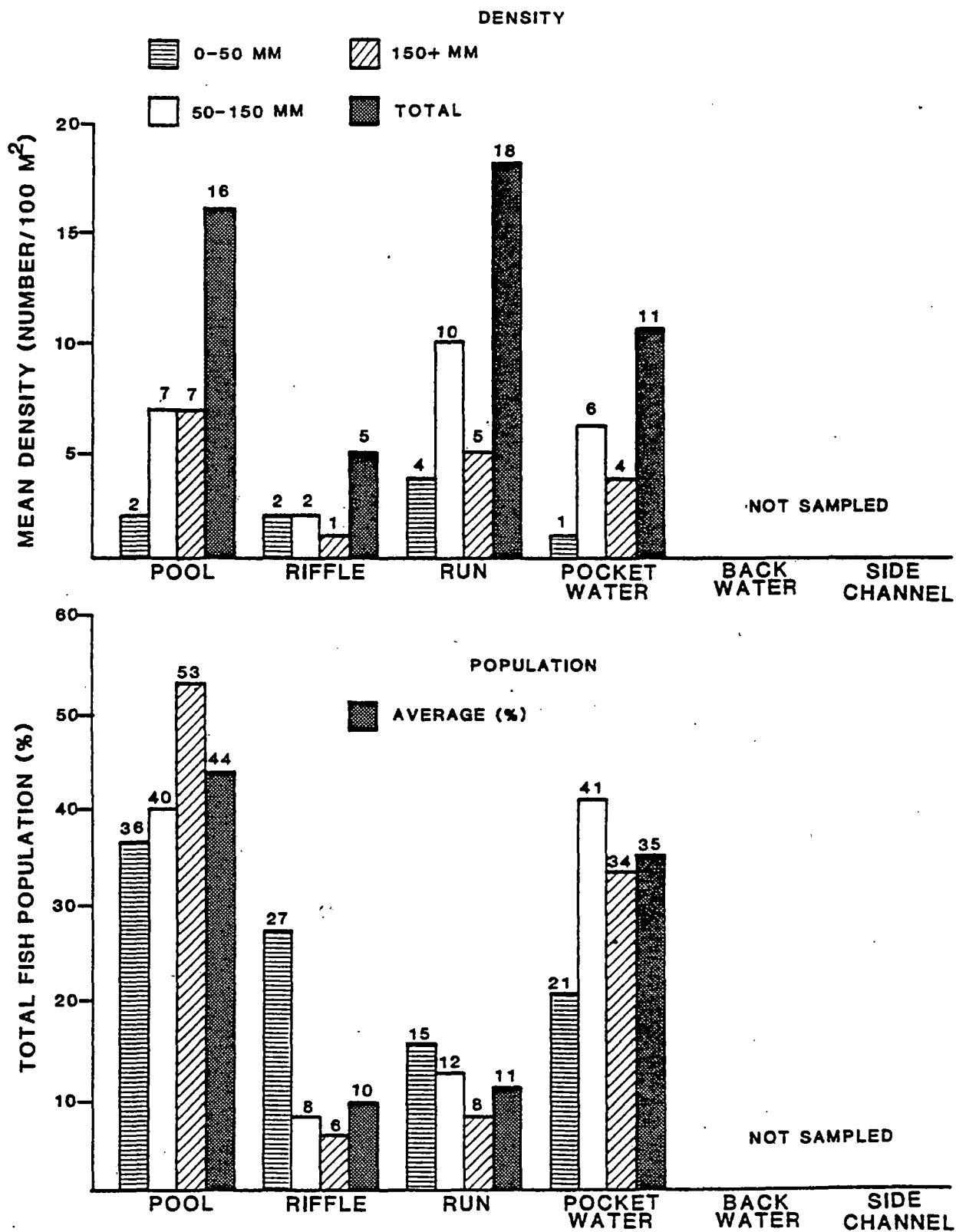


Figure 21. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in John's Creek, 1981.

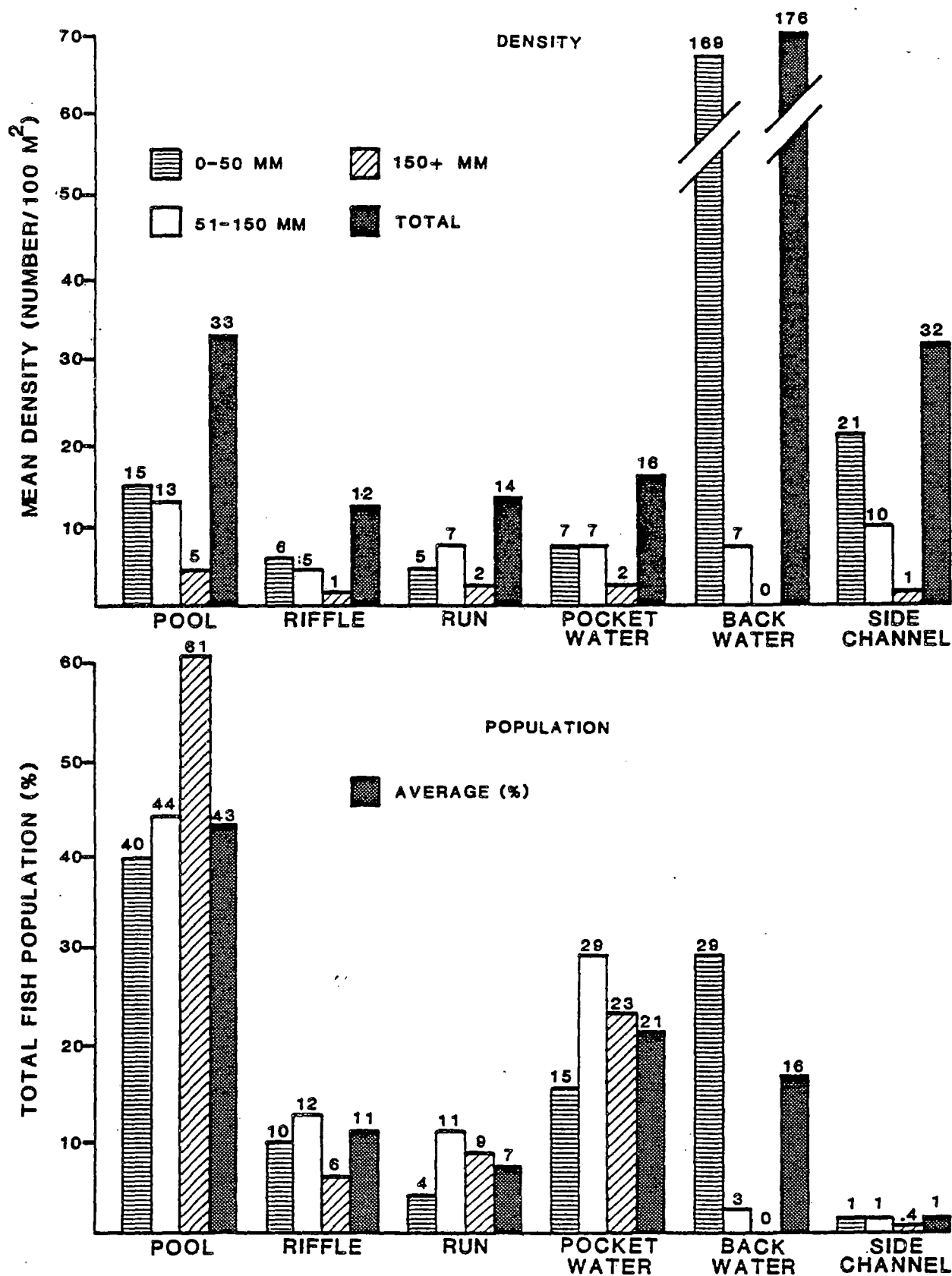


Figure 22. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in Tenmile Creek, 1979.

m²) followed by pocketwaters (10.0), riffles (7.0) and runs (7) (Figure 23).

Twentymile Creek: In Twentymile Creek during 1980 average fish densities were highest in backwaters (41.0 fish per 100 m²) followed by pools (24.0), side channels (11.0), runs (10.0), pocketwater (8.0) and riffles (3.0) (Figure 24). In 1981 fish densities were highest in pools and pocketwaters (13.0 fish per 100 m²) followed by runs (10.0), and riffles (3.0) (Figure 25).

Mill Creek: In Mill Creek during 1979 average fish densities were highest in pools (31.0 fish per 100 m²) followed by runs (26.0), pocketwaters (21.0) and riffles (19.0) (Figure 26). In 1980 average densities were highest in runs (89.0 fish per 100 m²) followed by pools (57.0), pocketwaters (51.0) and riffles (38.0) (Figure 26).

West Fork of Red River: In the West Fork of Red River during 1979 average fish densities were highest in riffles (77.0 fish per 100 m²) followed by pools (56.0), runs (53.0) and pocketwaters (40.0) (Figure 27). In 1980 average fish densities were highest in pools (12.0 fish per 100 m²) followed by runs (11.0), pocketwaters (9.0) and riffles (1.0) (Figure 27).

Trapper Creek: In Trapper Creek during 1979 average total fish densities were highest in pools (32.0 fish per 100 m²) followed by runs (20.0), pocketwaters (10.0) and riffles (5.0) (Figure 28). In Trapper Creek during 1980 average total

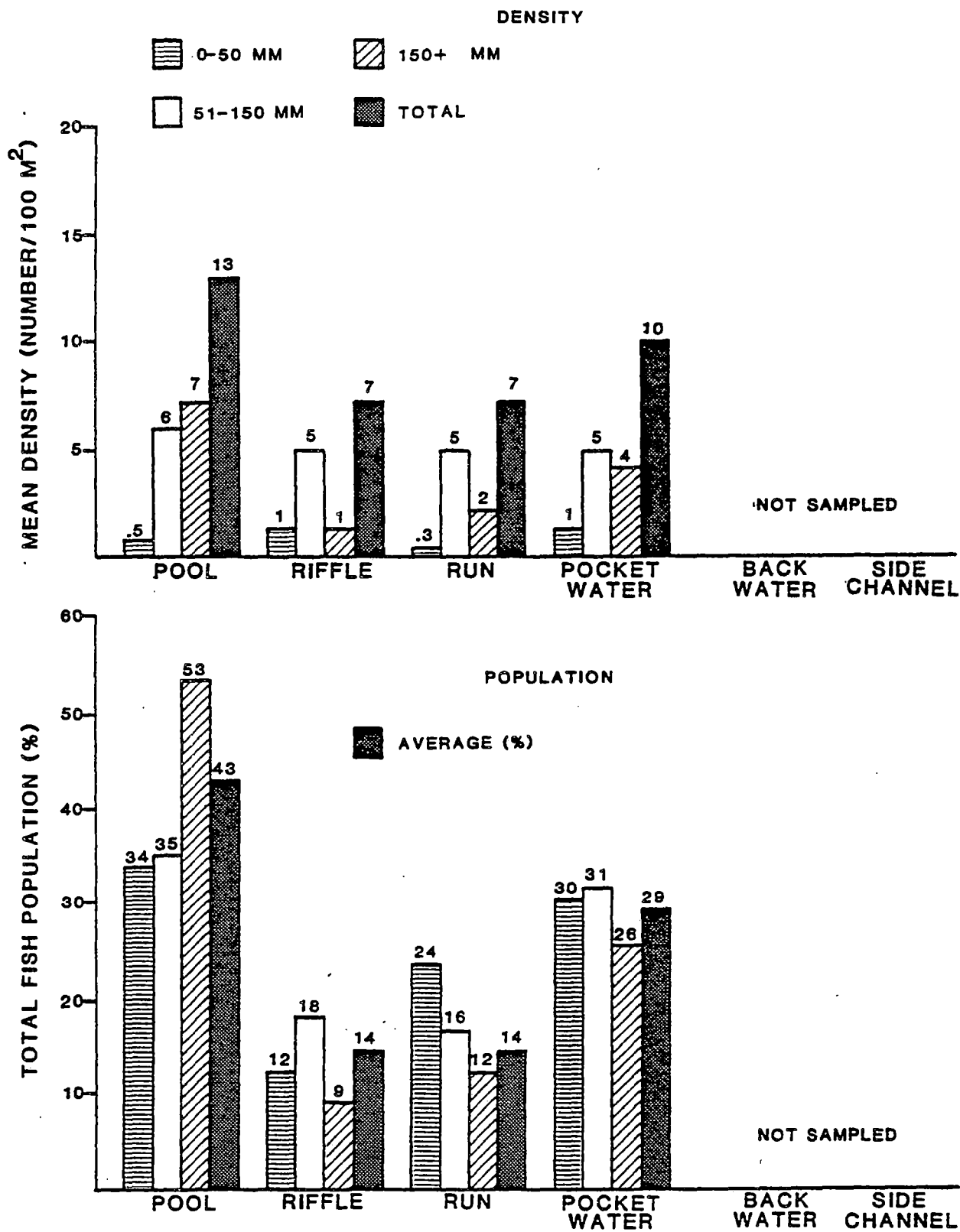


Figure 23. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in Tenmile Creek, 1981.

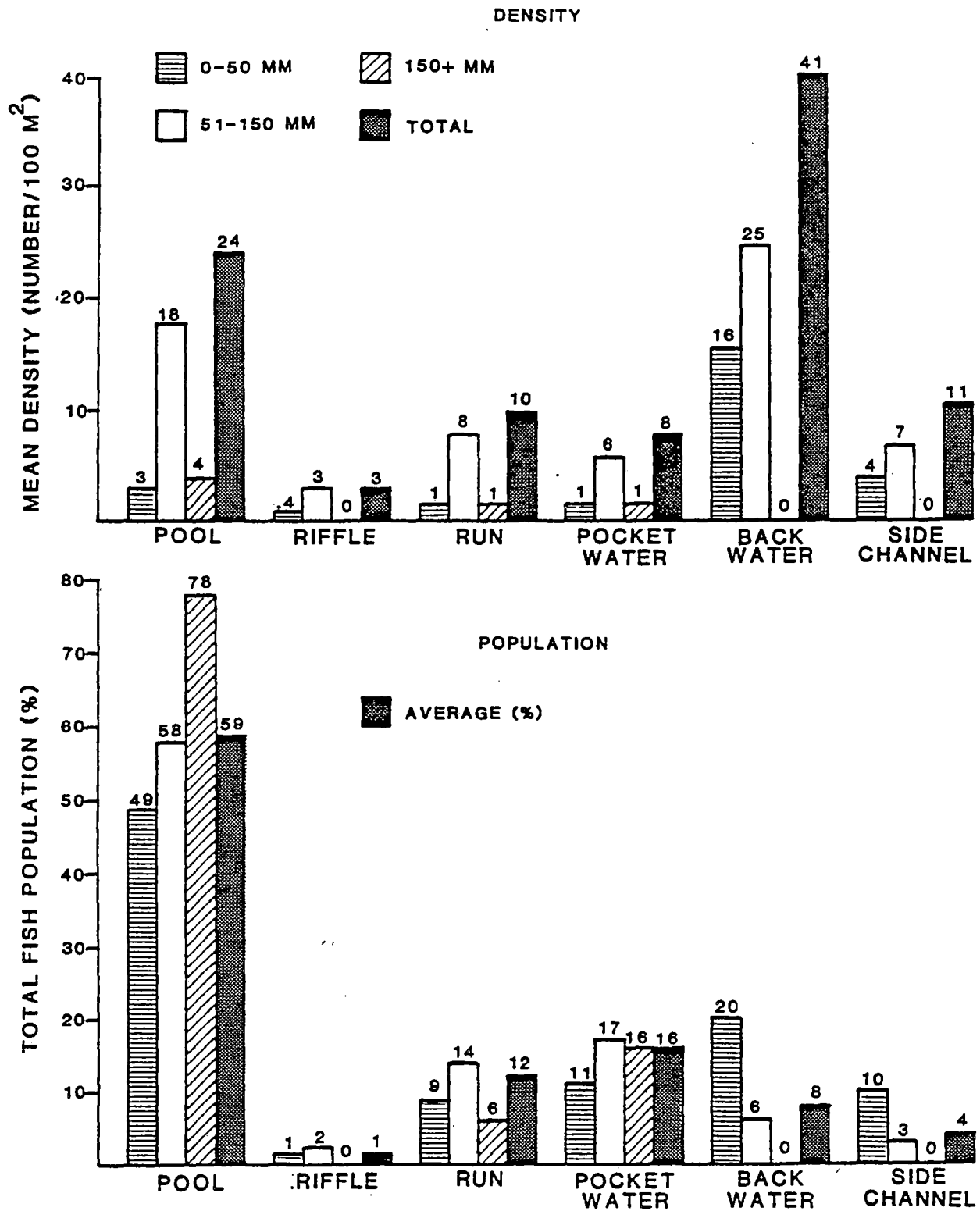


Figure 24. Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length in Twentymile Creek, 1980.

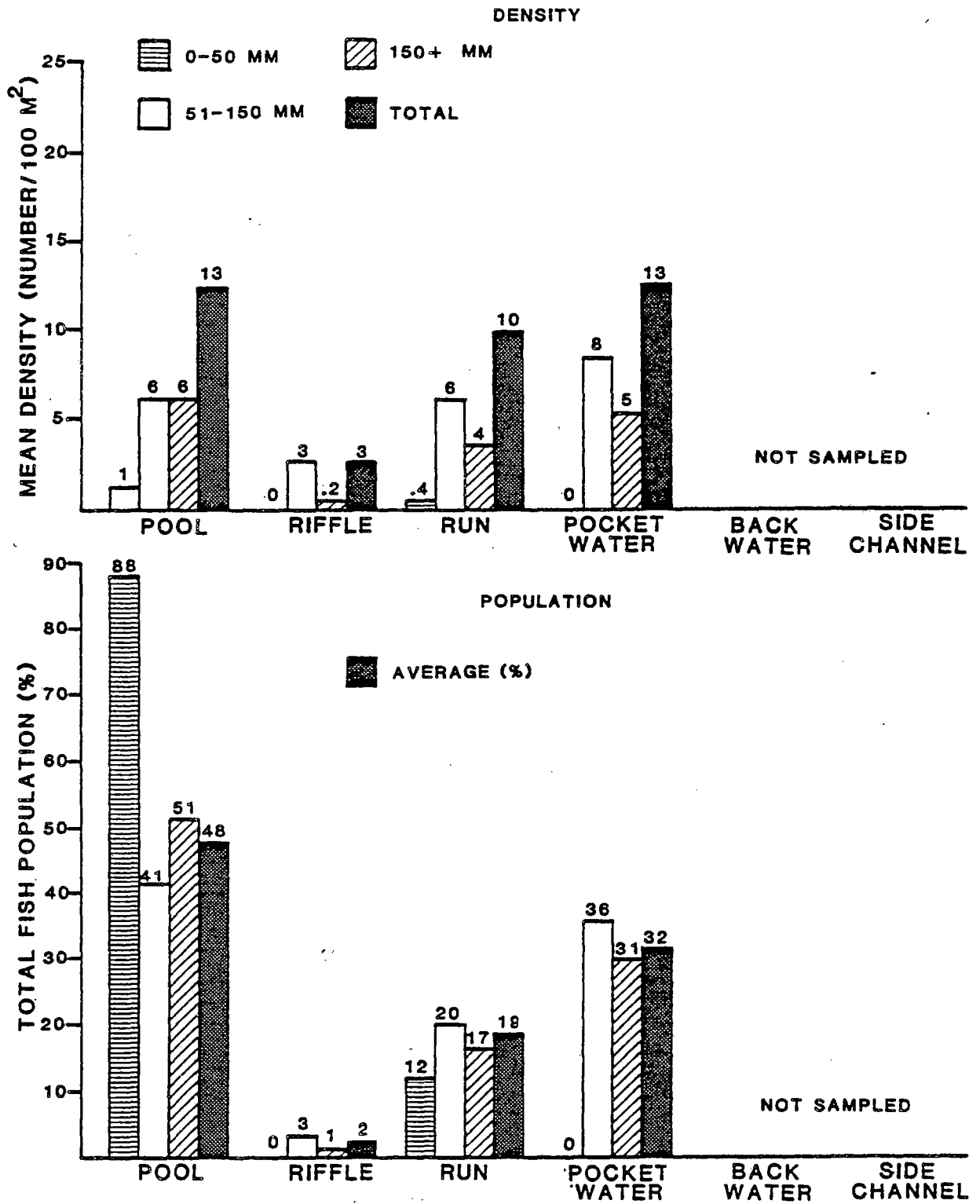


Figure 25, Mean fish density (upper) and percentage of total fish population (lower) by habitat type and length class in Sections 1-2 of Twentymile Creek, 1981

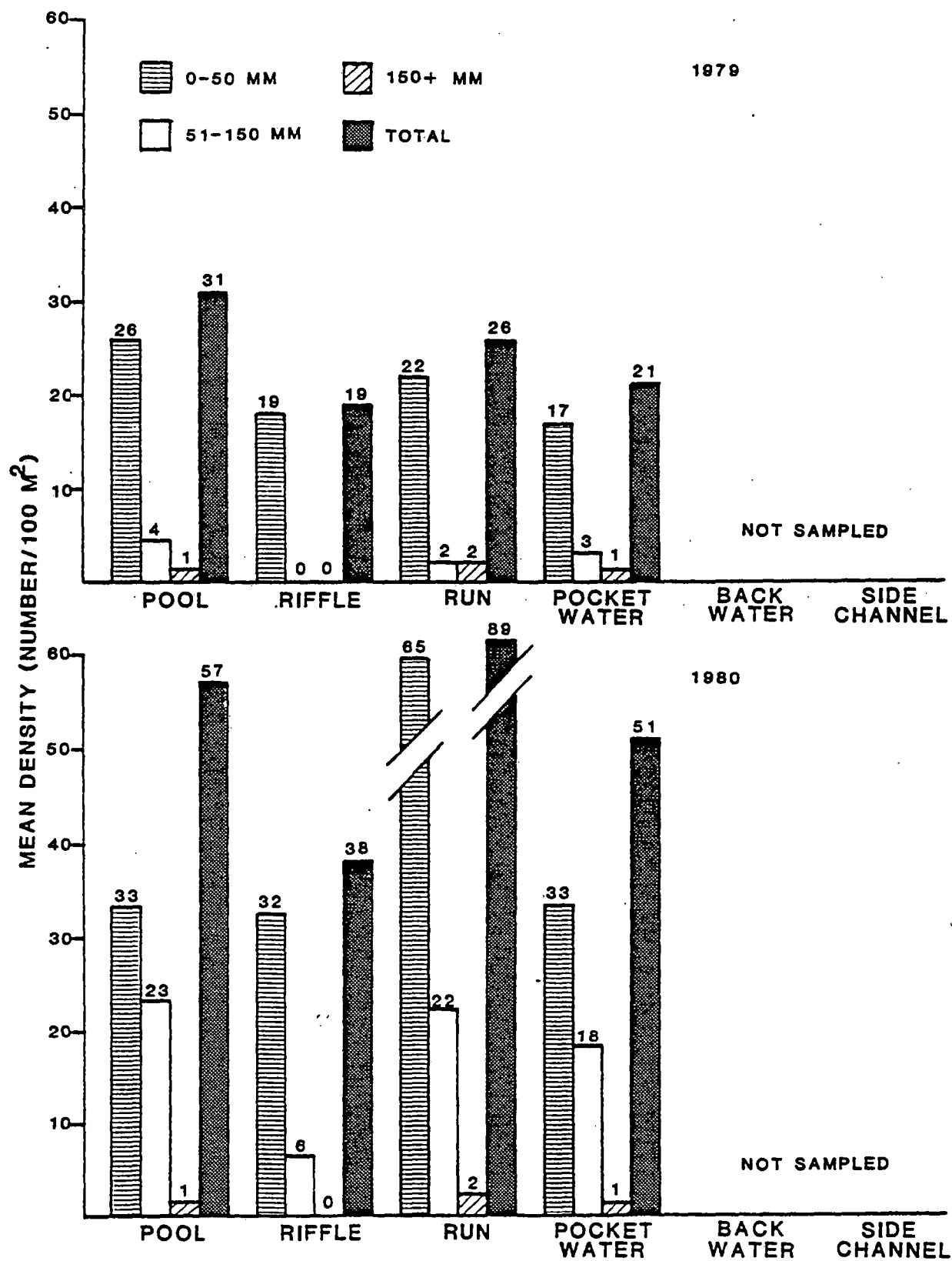


Figure 26. Mean fish density by habitat type and length class in Mill Creek during 1979 (upper) and 1980 (lower).

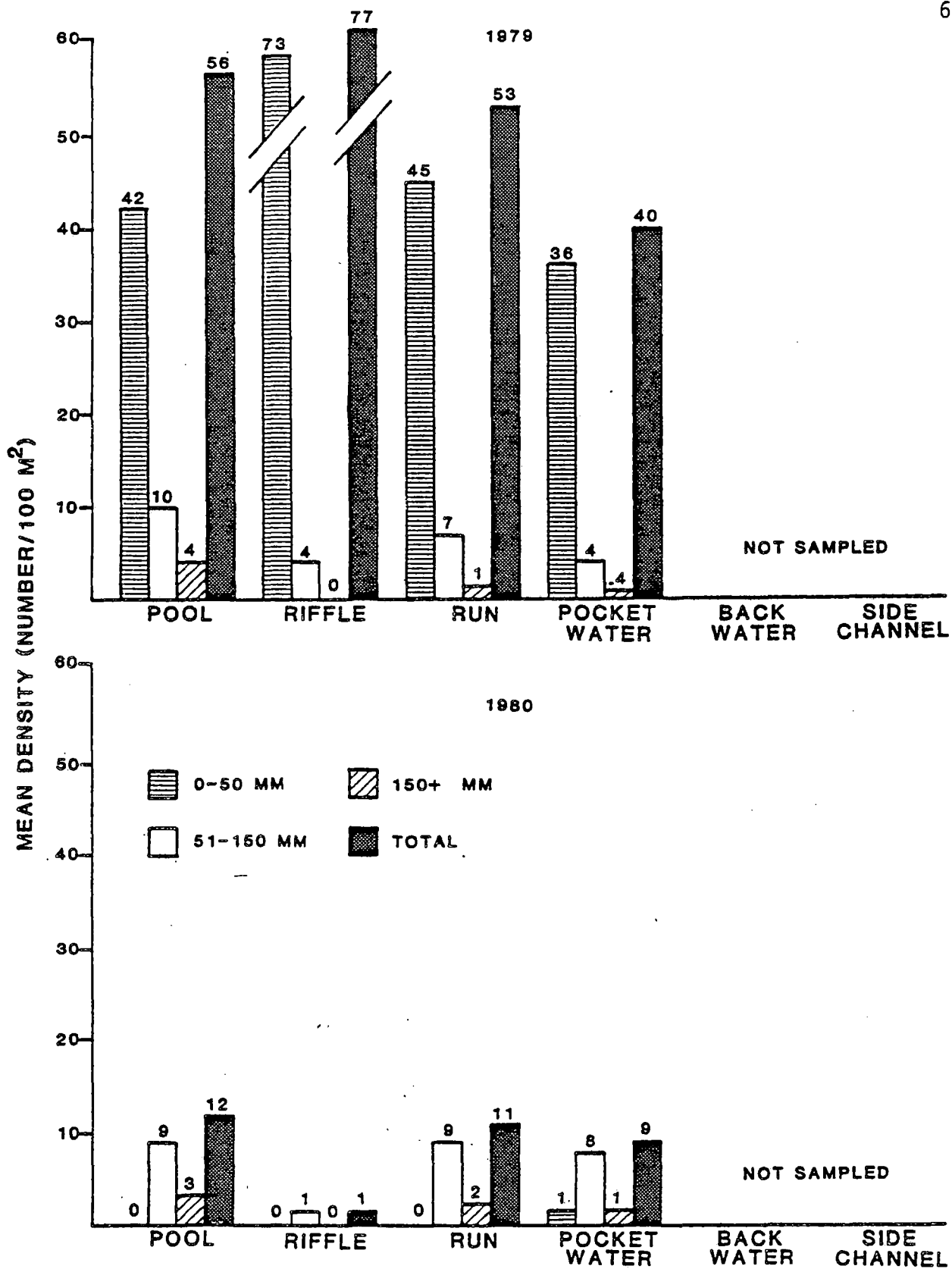


Figure 27. Mean fish density by habitat type and length class in West Fork Red River during 1979 (upper) and 1980 (lower).

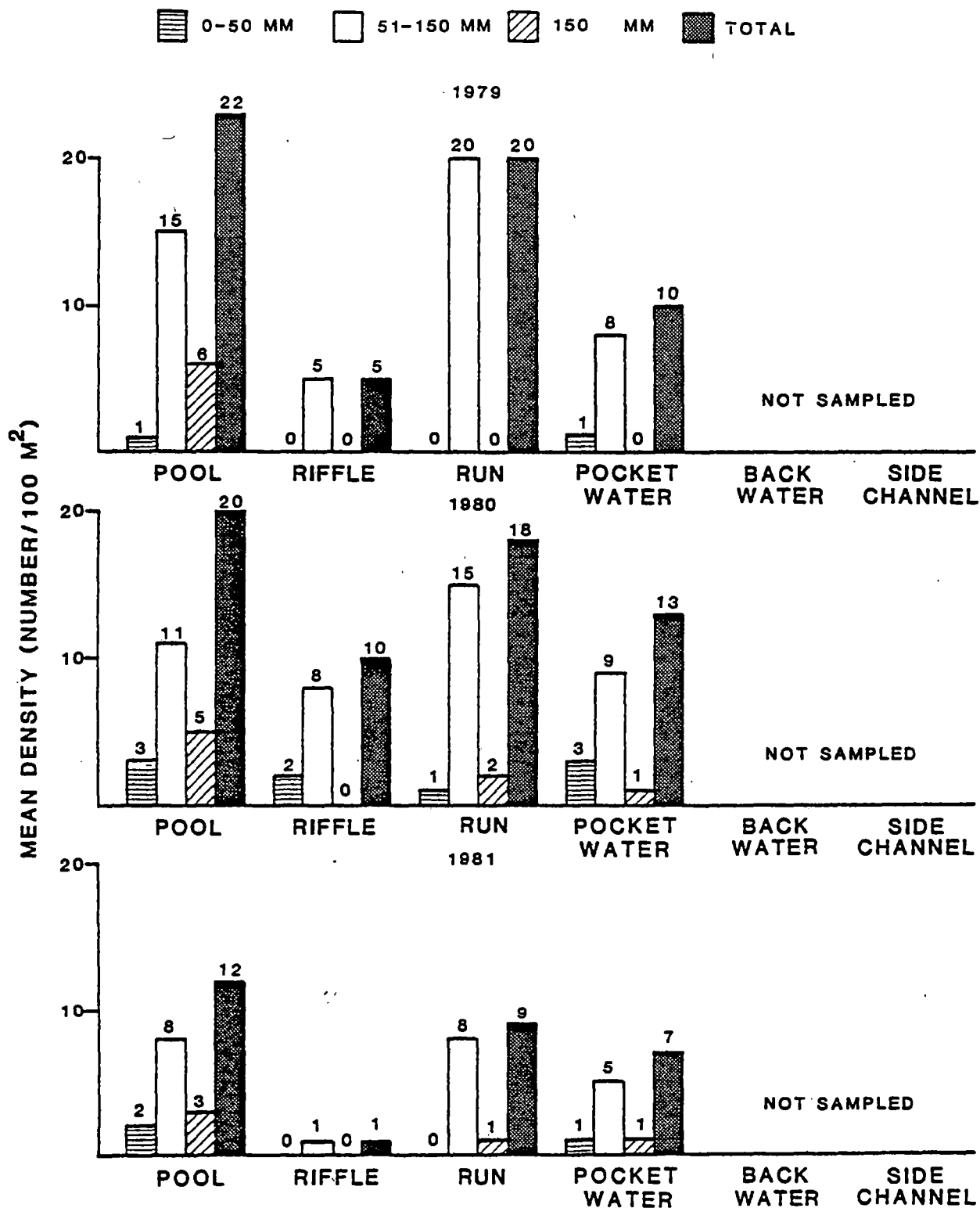


Figure 28. Mean fish density by habitat type and length in Trapper Creek during 1979 (upper), 1980 (middle) and 1981 (lower).

fish densities were highest in pools (20.0 fish per 100 m²) followed by runs (18.0), pocketwaters (13.0) and riffles (10.0) (Figure 28). In 1981 average total fish densities were highest in pools (12.0 fish per 100 m²) followed by runs (9.0) pocketwaters (7.0) and riffles (0.7) (Figure 28).

Distribution of Fish by Habitat Type

In Johns, Tenmile and Twentymile Creeks most fish were observed in pool and pocketwater habitats. However the distribution of individual size classes (0 to 50, 51 to 150 and longer than 150 mm) did not always follow this pattern.

Johns_Creek: In Johns Creek during 1979 most fry (27.0 and 31.0%), fish 50 to 150 mm (42.0 and 38.0%) and fish longer than 150 mm (49.0 and 39.0%) were observed in pools and pocketwaters, respectively (Figure 20). In 1981 most fish 50 to 150 (40.0 and 41.0%) and longer than 150 mm (53.0 and 34.0%) were observed in pools and pocketwaters, respectively (Figure 21). However, most fry (36.0 and 27.0%) were observed in pools and riffles (Figure 21). Although pocketwaters comprised more habitat (40.4%) than other habitat types more fish were observed in pools during 1979 (35.2%) and 1981 (44.0%) (Figures 20 and 21). No large fish (150+ mm) were observed in backwater habitats (Figure 20). Rainbow/steelhead dominated all habitats both in 1979 and 1981. In 1979 rainbow/steelhead comprised 100% of the fish observed in backwater and side channel habitats (Appendix C, Table C-1).

Tenmile Creek: In Tenmile Creek during 1979 most fish 50 to 150 (40.0 and 29.0%) and fish longer than 150 mm (61.0 and 23.0%) were observed in pools and pocketwaters, respectively (Figure 22). Most fry (40.0 and 29.0%) were observed in pools and backwaters, respectively (Figure 22). In 1981 most fry (34.0 and 30.0%), fish 50 to 150 mm (35.0 and 31.0%) and fish longer than 150 mm (53.0 and 26.0%) were observed in pools and pocketwaters, respectively (Figure 23). No large fish (150+ mm) were observed in backwater habitats (Figure 22). During 1979 and 1981 rainbow/steelhead dominated all habitats except backwater areas where chinook salmon dominated in 1979 (Appendix C, Table C-2). Chinook salmon a co-dominate in 1979 was not observed in 1981.

Twentymile Creek: In Twentymile Creek during 1980 most fry (49.0 and 20.0%) were observed in pools and backwaters, respectively (Figure 24). Most fish 51 to 150 (58.0 and 17.0%) and longer than 150 mm (78.0 and 16.0%) were observed in pools and pocketwaters, respectively (Figure 24). In 1981 all fry (88.0 and 12.0%) were located in pools and runs, respectively (Figure 25). Most fish 51 to 150 (41.0 and 36.0%) and fish longer than 150 mm (51.0 and 31.0%) were observed in pools and pocketwaters, respectively (Figure 25). In 1980 no large fish (150+ mm) were observed in riffles, backwaters or side channels (Figure 24). In 1981 no fry were observed in riffles or pocketwaters (Figure 25). Cutthroat trout dominated all habitats in 1980 and 1981 (Appendix C, Table C-3).

Estimate of Fish Population Size

In terms of total population size most fish utilized pool and pocketwater habitat types. However, the highest densities occurred in backwater areas (Figures 20, 22 and 24). The fact that pools and pocketwaters have a larger surface area than backwaters explains this change in relative importance. Backwater areas are usually composed mostly of fry (0 to 50 mm), thus are important as rearing areas. Estimates of fish populations are a minimum since fish are more likely to be missed than recounted in snorkel transects.

Johns Creek: The estimated number of fish present in the MRDA portion of Johns Creek during 1979 and 1981 were 18,928 and 3,004, respectively, for all species 0 to 50 mm in length, 9,262 and 10,498 51 to 150 mm in length and 6,455 and 7,655 longer than 150 mm (Table 6 and Figure 29). Fish population size decreased (34,645 to 21,157) from 1979 to 1981 (Table 6). Most of the decreased occurred in fish 0 to 50 mm in length (18,928 to 3,004).

Tenmile Creek: The estimated number of fish present in the MRDA portion of Tenmile Creek during 1979 and 1981 were 10,444 and 215, respectively, for all species in the 0 to 50 mm length class, 7,275 and 4,337 in the 51 to 150 mm length class and 2,027 and 3,723 longer than 150 mm (Table 6 and Figure 30). Fish population size decreased in all sections between 1979 and 1981 (Table 6). Sections 1 and 3 decreased by 65 and 66% while sections 2 and 4 decreased by 35 and 28%, respectively.

Table 6. Population estimates by species and length class in Johns, Tennesse and Twentymile Creeks (1979, 1980 & 1981)
(95% confidence interval of estimate in parentheses).

Creek-Year (n)	Trout								Whitefish			Chinook salmon		Total		
	Pcy	Hb/Sb		Cutthroat		Bull		Age 0				Age 1				
	0-50 (nn)	51-150 (nn)	150+ (nn)	51-150 (nn)	150+ (nn)	51-150 (nn)	150+ (nn)	0-50 (nn)	51-150 (nn)	150+ (nn)	0-50 (nn)	51-150+ (nn)	150+ (nn)			
Johns-1979 (69)	18,928 (3,238)	8,739 (1,762)	5,790 (1,162)	157 (151)	129 (110)	0 (-)	129 (99)	0 (-)	0 (-)	407 (316)	0 (-)	365 (433)	18,928 (3,053)	9,262 (2,178)	6,455 (1,303)	
Johns-1981 (48)	3,004 (1,072)	10,342 (2,285)	6,899 (1,322)	100 (111)	0 (-)	56 (82)	89 (102)	0 (-)	0 (-)	667 (402)	0 (-)	0 (-)	3,004 (1,072)	10,498 (2,333)	7,655 (1,454)	
Tennile-1979 (118)	2,761 (1,202)	6,821 (902)	1,480 (281)	208 (135)	53 (38)	33 (32)	277 (102)	0 (-)	0 (-)	217 (85)	7,743 (1,925)	142 (101)	10,444 (2,464)	7,275 (959)	2,027 (353)	
Tennile-1981 (91)	215 (93)	4,228 (667)	3,029 (631)	149 (104)	109 (60)	60 (55)	172 (83)	0 (-)	99 (128)	414 (306)	0 (-)	0 (-)	215 (93)	4,337 (758)	3,723 (813)	
Twentymile-1980 (83)	1,114 (605)	1,167 (446)	241 (142)	5,562 (1,603)	906 (328)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1,658 (605)	7,919 (1,829)	1,195 (411)	
Twentymile-1981 (51)	266 (335)	16 (34)	0 (-)	2,635 (1,011)	2,035 (1,037)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	266 (335)	2,251 (1,020)	2,035 (1,037)	
West Fork of Twentymile-1980 (17)	101 (91)	51 (72)	0 (-)	835 (385)	25 (50)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	101 (91)	886 (408)	25 (50)	

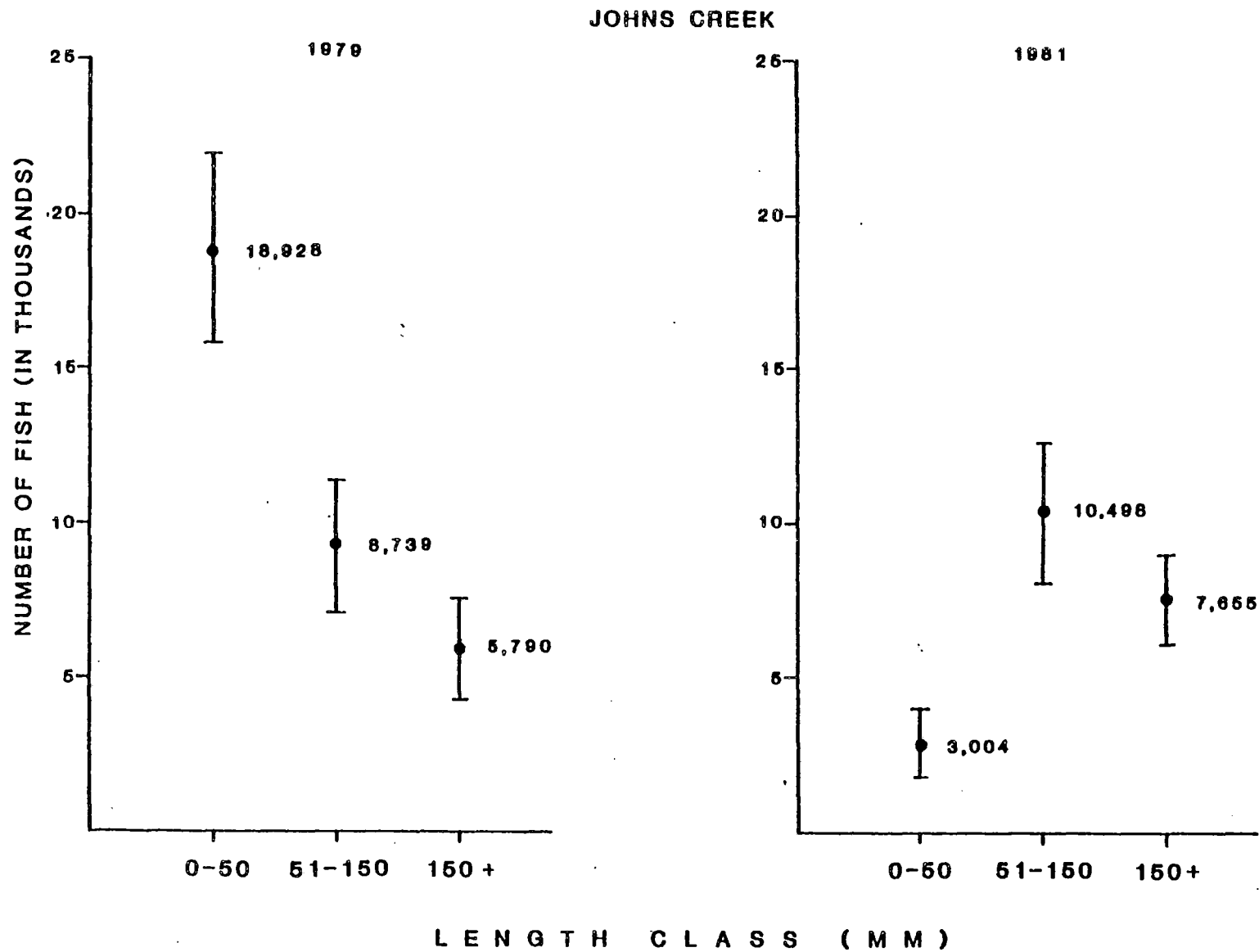


Figure 29. Population estimates and 95% confidence levels for all fish species in the MRDA portion of Johns Creek during the summers 1979 and 1981.

TENMILE CREEK

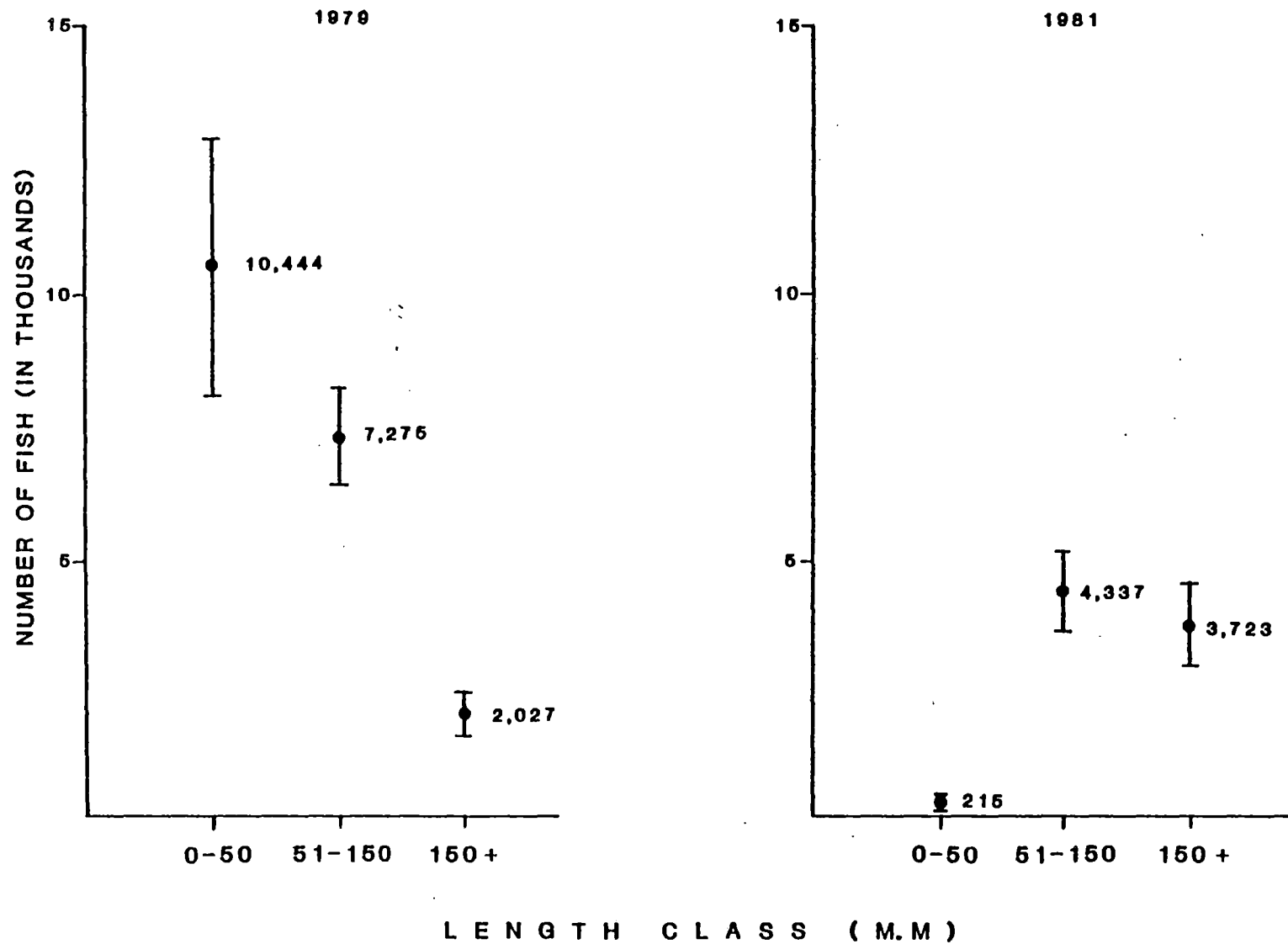


Figure 30. Population estimate and 95% confidence interval for all fish species in the MEDA portion of Tenmile Creek during summer 1979 and 1981.

Twentymile Creek: The estimated number of fish present in the MRDA portion of Twentymile Creek during 1980 and 1981 were 1,759 and 266, respectively, for all species in the 0 to 50 mm length class, 8,805 and 2,651 in the 51 to 150 mm length class and 1,221 and 2,035 longer than 150 mm (Table 6 and Figure 31). Fish population size remained about the same in section 3 between 1980 and 1981 (4,326 to 4,324) , but decreased in section 2 (2,620 to 629) (Table 6). The decrease was from fish 0 to 50 and 51 to 150 mm in length. Sections 1 and 4 were not sampled in 1981.

Fish Movement

Relatively few fish moved downstream out of Johns and Tenmile Creeks during the late summer-fall period the weirs were operated in 1980. Forty-five rainbow/steelhead juveniles, sixteen age 0 chinook salmon, one mountain whitefish and seven other fish (including sculpins, dace and two bull trout) entered the downstream trap in Johns Creek. Six rainbow/streelhead juveniles, four age 0 chinook salmon and three mountain whitefish entered the downstream trap in Tenmile Creek. Water temperatures and rainstorms seemed to trigger downstream movement.

I believe both traps should have been operated later into the fall, after water temperatures dropped below 4 C. It appeared the number of outmigrating salmonids was increasing

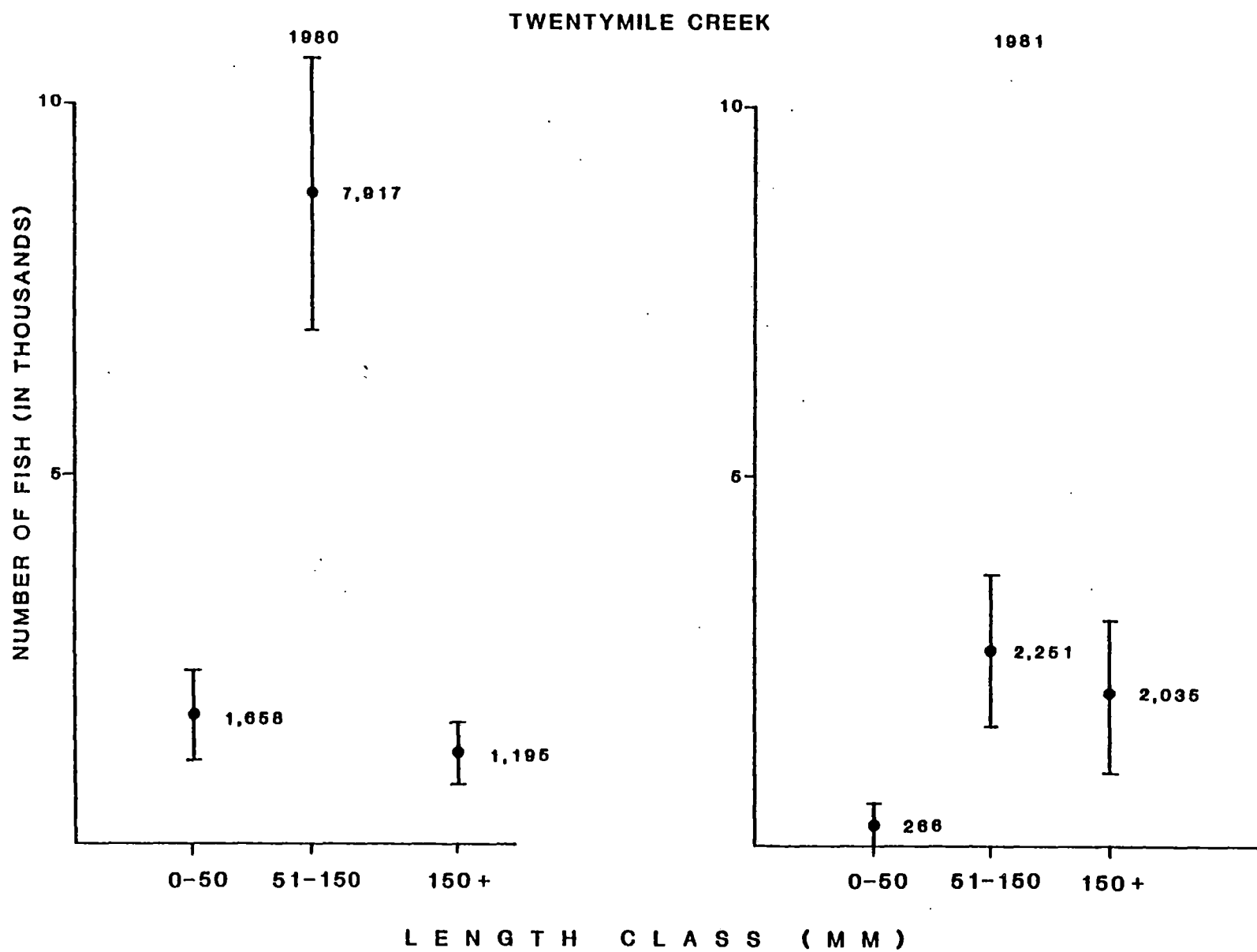


Figure 31. Population estimates and 95% confidence interval for all fish species in the MRDA portion of Twentymile Creek during summers 1980 and 1981.

when trapping operations were terminated due to the expense of traveling to the study site on a weekly basis.

Both Tenmile and Johns Creeks have over wintering habitat and it may not have been necessary for fish to migrate downstream in the fall. The substrate in Johns Creek consisted of large cobble and boulder material and Tenmile Creek had abundant pools with substantial amounts of unsedimented cobble and boulder substrate which provides over winter habitat (Figures 5 and 7).

MODELS

Historically, the evaluation of sediment effects on fish habitat and populations have been one-step evaluation. The models developed in this study are multiple-step which may provide more accuracy.

Four models were developed to evaluate the interactions between timber management activities, sediment, and fish resources in the Gospel-Hump MRDA. The vegetation, stream-hydrologic, and watershed-soil models were combined into one model referred to as SNCWSED (SNOWmelt-SEDiment) and described in detail by Simons, et al (1981).

SnowSed Model

The vegetation model predicted volume and productivity of timber through time for different management alternatives. It provided the major link between proposed management activities and the watershed model by estimating changes in forest cover. The stream-hydrologic model simulated streamflow and sediment transport in streams. The watershed-soils model predicted natural and post-harvest land and streambed sediment properties needed to drive the stream-hydrologic model.

Fisheries Model

In many forest streams fish abundance is limited by fry survival, summer rearing capacity, or winter carrying capacity. Fry production can be thought of as the number of fry which

emerge from the gravel. Fry production can be limited by the amount of spawning habitat available, the seeding rate (number of spawners), or the egg emergent survival (Johnson 1965, Argue et al. 1979, Bjornn 1978), which can be affected by fine sediment.

Juvenile and adult salmonid abundance can be limited by the amount of rearing habitat available (Chapman and Bjornn 1969). These habitats may be segregated into summer areas consisting primarily of pools and runs or over-winter holding areas consisting primarily of interstitial spaces in the substrate (Bjornn et al. 1977, Eustard and Narver 1975a, Everest 1969, Chapman 1966, Morrill and Bjornn 1972). Deep pools are also used to over-winter and in many western streams over-winter habitat would become limited with increases in sediment deposition before summer rearing space was filled with sediment (Klart 1976). In some small streams fish over-wintering in downstream location (Keating 1958, Reingold 1965, Bjornn 1971 and 1978, Eustard and Narver 1975) or migrating to larger streams may eliminate winter habitat as a limiting factor. In these streams summer rearing may limit fish abundance.

The fisheries model, using output from the stream-hydrologic model, predicts changes in 1) cobble embeddedness of pools, riffles and runs, 2) pool volumes and 3) fish abundance (percent change).

Sediment-Habitat Relationships

The stream-hydrologic model provides output in terms of the percentage, distribution, and quantity of sediment sizes that occur in a critical stream reach. The link between the stream-hydrologic and fisheries models was made by using a relationship developed at the University of Idaho (Figure 32).

Laboratory studies were conducted to determine the relationship between cobble embeddedness and sediment size distribution. We added a standard mixture of fine material (< 25.4 mm in size) to a standard mixture of cobble (> 25.4 mm in size). Corresponding embeddedness levels and amounts of fine sediment added were recorded. Using the SAS STEPWISE computer package at the University of Idaho (SAS Institute 1979) regression analysis was used to develop the best relationship (equation) between the percentage of fine sediment (< 25.4 mm in size) and embeddedness level (Figure 32).

Habitat-Fish Response Curves

The fisheries model predicts changes (increases or decreases) in fish abundance in terms of embryo survival (fry production), summer rearing capacity, and winter carrying capacity. Embryo survival in riffles was estimated using percentages of substrate smaller than 0.85 and 9.5 mm in size and relationships developed by Tappie (1982) (Appendix D, Tables D-1 and D-2). Summer rearing capacity in runs and pools was estimated using cobble embeddedness levels, pool volumes, and

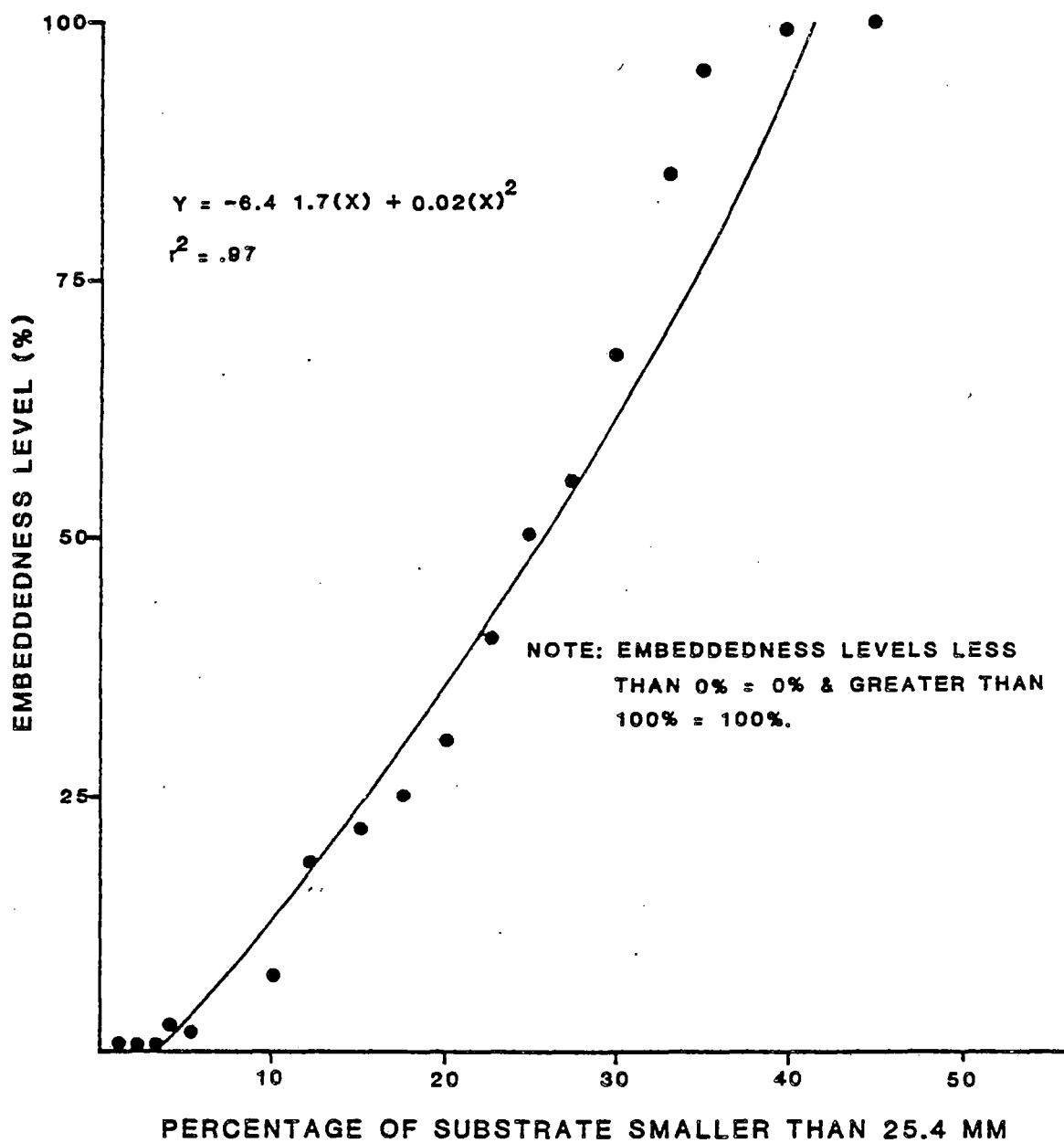


Figure 32. Relationship between substrate particle size and embeddedness level.

relationships developed by Bjornn, et al (1977) (Appendix D, Figures D-3 and D-4). Winter carrying capacity in pools was estimated using cobble embeddedness levels and relationships developed by Bjornn, et al (1977) (Appendix D, Figure D-5).

Using the output from the stream-hydrologic and fisheries models the following step-by-step procedure was used to evaluate the effect of sediment on fish populations in the Gospel-Hump MRDA.

Step 1: Determine existing values for embryo survival, summer rearing capacity, and winter carrying capacity using baseline data and relationships based on fish abundance, habitat parameters, cobble embeddedness, and the percentage of fine sediment (Figure 32 and Appendix D).

Step 2: Using the SnowSed model predict the size and deposition of sediment and embeddedness levels in stream habitat types (pools, riffles, and runs) caused by proposed management activities.

Step 3: Using the fisheries model predict the percentage changes in embryo survival, summer rearing capacity, and winter carrying capacity between existing and predicted data (Appendix D).

Step 4: Determine which factor limits fish abundance.

Because of time and money constraints only Tenmile and Twentymile Creeks were used in the modeling process. Alternatives modelled were 1) Current Management (A), 2) Minimum Management (E), 3) Mountain Pine Beetle Departure, 4) Noncommodity Emphasis (E) and 5) Maximum Management (G). For each alternative the Fisheries model predicts, with two exceptions, an increase in embryo survival, summer rearing

Table 7. Embryo survival, summer rearing capacity, and winter carrying capacity of trout and age 0 steelhead and chinook salmon in Tenmile Creek on October 1 of each year modeled for alternatives A, B, D and E.

Year	Embryo Survival (%)		Summer rearing capacity (%)			Winter carrying capacity (%)		
	Age 0		Age 0			Age 0		
	chinook salmon	Trout	steel-head	chinook salmon	Trout	steel-head	chinook salmon	Trout
Alternative A-Current Management								
1985	93.9	96.4	83.5	94.9	76.9	17.9	21.2	12.1
1986	93.2	100.0	91.0	97.8	82.5	28.4	32.2	21.3
1987	92.7	100.0	90.3	97.1	81.8	26.4	30.2	19.5
Alternative B-Minimum Management								
1985	93.9	96.4	83.5	94.9	76.9	17.9	21.2	12.1
1986	93.2	98.5	91.0	97.8	82.5	28.4	32.2	21.3
1987	92.7	100.0	90.3	97.1	81.8	26.4	30.2	19.5
1988	92.6	100.0	94.4	99.1	85.8	35.6	39.5	28.2
1989	92.1	100.0	95.4	99.5	87.0	36.0	39.9	28.6
1990	91.8	100.0	95.6	99.5	87.1	36.9	40.8	29.4
1991	91.9	100.0	95.7	99.1	87.5	42.5	46.3	35.0
Alternative D-Mountain Pine Beetle Departure								
1985	93.9	96.4	83.5	94.9	76.9	17.9	21.2	12.1
1986	93.2	100.0	91.0	97.8	82.5	28.4	32.2	21.3
1987	92.7	100.0	90.3	97.1	81.8	26.4	30.2	19.5
Alternative E-Noncommodity Emphasis								
1985	93.9	96.4	83.5	94.9	76.9	17.9	21.2	12.1
1986	93.2	98.5	91.0	97.8	82.5	28.4	32.2	21.3
1987	91.7	100.0	90.3	97.1	81.8	26.4	30.2	19.5
1988	92.6	100.0	94.4	99.1	85.8	35.6	39.5	28.2
1989	92.1	100.0	95.4	99.5	87.0	36.0	39.9	28.6
1990	91.7	100.0	94.9	99.2	86.3	34.9	38.8	27.5
1991	91.7	100.0	96.3	99.9	88.0	41.5	45.4	34.0

Table 8. Embryo survival, summer rearing capacity, and winter carrying capacity of trout, age 0 steelhead and chinook salmon in Twentymile Creek on October 1 of each year modeled for alternatives B and G.

Year	Embryo Survival (%)		Summer rearing capacity (%)			Winter carrying capacity (%)		
	Age 0		Age 0		Age 0	Age 0		Age 0
	chinook	chinook	steel-	chinook	chinook	steel-	chinook	chinook
	salmon	Trout	head	salmon	Trout	head	salmon	salmon
Alternative B-Minimum Management								
1984	93.9	96.4	83.5	94.9	76.9	17.9	21.2	12.1
1985	94.3	96.0	91.6	97.1	82.9	30.4	34.2	23.2
1986	94.4	96.0	91.2	82.6	82.5	28.0	31.8	21.0
1987	94.5	95.9	92.2	95.8	83.9	33.1	37.0	25.8
1988	94.5	95.5	93.6	96.3	85.7	38.9	42.7	31.3
1989	94.4	96.6	93.9	96.3	86.3	39.5	43.4	32.1
Alternative G-Maximum Management								
1984	93.9	96.4	83.5	94.9	76.9	17.9	21.2	12.1
1985	94.2	96.6	90.6	96.6	82.0	28.2	32.1	21.2
1986	94.3	96.7	90.5	96.4	81.8	26.4	30.2	19.5
1987	94.4	96.4	91.7	95.5	83.3	32.5	36.3	25.1
1988	94.4	96.6	93.2	96.0	85.2	38.1	41.9	30.6
1989	94.3	97.3	93.6	96.2	85.8	38.6	42.5	31.1

capacity and winter carrying capacity in Tenmile and Twentymile Creeks (Tables 7 and 8). The model predicts a decrease in trout and steelhead embryo survival in Tenmile Creek (Table 7).

This analysis assumes that outputs from the watershed model and the sediment-fish relationships are reasonably accurate. We believe it unreasonable to expect an increase in survival and holding capacity for all alternatives over a 6 to 7 year period. Therefore we compared the relative changes between alternatives.

We compared alternatives by calculating percentage change in embryo survival, summer rearing capacity, and winter carrying capacity between the first year modeled (present condition) and the last year modeled (predicted condition). Comparisons were made on October 1 of each year. In Tenmile Creek we compared years 1 and 3 (1985 and 1987) of alternatives A, B, D, and E and years 1 and 7 (1985 and 1991) of alternatives B and E. In Twentymile Creek we compared years 1 and 6 (1984 and 1989) of alternatives B and G.

Tenmile Creek: There was no difference between alternative A, B, D, and E when comparing years 1 and 3 in Tenmile Creek. The relative change in embryo survival, summer rearing capacity, and winter carrying capacity was the same for each alternative (Table 9).

There was little difference between alternatives B and E when comparing years 1 and 7. Differences in the relative change between alternatives B and E were 0.21% for trout and

Table 9. The percentage change and difference between the first and last year modeled in Tenmile Creek for alternatives A, B, D and E ("+" equals increase and "-" decrease).

Limiting factor Species	Percentage change between years 1 and 3				Percentage difference
	Alternatives				
	A	B	D	E	
Embryo survival					
Trout	-1.28	-1.28	-1.28	-1.28	0
Steelhead	-1.28	-1.38	-1.28	-1.28	0
Chinook salmon	+3.73	+3.73	+3.73	+3.73	0
Summer rearing capacity					
Trout	+8.14	+8.14	+8.14	+8.14	0
Steelhead	+2.32	+2.32	+2.32	+2.32	0
Chinook salmon	+6.37	+6.37	+6.37	+6.37	0
Winter carrying capacity					
Trout	+47.49	+47.49	+47.49	+47.49	0
Steelhead	+42.45	+42.45	+42.45	+42.45	0
Chinook salmon	+61.16	+61.16	+61.16	+61.16	0

steelhead and 0% for chinook salmon embryo survival (Table 10). The relative change between alternatives B and E for summer rearing and winter carrying capacity was 0.72, 0.84 and 0.65% and 5.59, 4.25, and 8.27% for trout, steelhead and chinook salmon, respectively (Table 10).

Twentymile Creek: There was little difference (1.0%) between alternatives B and G when comparing years 1 and 3 in Twentymile Creek. The relative change between alternatives B and G was 0.10, 0.10, and 0.72% for trout, steelhead, and chinook salmon embryo survival, respectively (Table 11). The relative changes between alternatives B and G were 0.36, 0.11, and 0.65% and 5.03, 4.25 and 8.27% for trout, steelhead, and chinook salmon summer rearing and winter carrying capacities, respectively (Table 11).

If the watershed model and sediment-fish relationships reasonably predict sediment transport, deposition, size class distribution, and effects of sediment on fish accurately we conclude there are no significant differences between alternatives in either Tenmile or Twentymile Creeks. However, professional judgement would dictate caution when interpreting these results because of the way the watershed model calculates sediment transport off the planes and through habitat types.

Table 10. The percentage change and difference between the first and last year modeled in Tenmile Creek for alternatives B and E ("+" equals increase and "-" decrease).

Limiting factor Species	Percentage change between years 1 and 7		Percentage difference
	Alternatives		
	B	E	
Embryo survival			
Trout	-2.13	-2.34	0.21
Steelhead	-2.13	-2.34	0.21
Chinook salmon	+3.73	+3.73	0
Summer rearing capacity			
Trout	+14.61	+15.33	0.72
Steelhead	+ 4.43	+ 5.27	0.84
Chinook salmon	+13.78	+14.43	0.65
Winter carrying capacity			
Trout	+137.43	+131.84	5.59
Steelhead	+118.40	+114.15	4.25
Chinook salmon	+189.26	+180.99	8.27

Table 11. The percentage change and difference between the first and last year modeled in Twentymile Creek for alternatives B and G ("+" equals increase and "-" decrease).

Limiting factor Species	Percentage change between years 1 and 6		Percentage difference
	Alternatives		
	B	G	
Embryo survival			
Trout	+0.53	+0.43	0.10
Steelhead	+0.53	+0.43	0.10
Chinook salmon	+0.21	+0.93	0.72
Summer rearing capacity			
Trout	+12.46	+12.10	0.36
Steelhead	+ 1.48	+ 1.37	0.11
Chinook salmon	+12.22	+11.57	0.65
Winter carrying capacity			
Trout	+120.67	+115.64	5.03
Steelhead	+104.72	+100.47	4.25
Chinook salmon	+165.29	+157.02	8.27

LITERATURE CITED

- Argue, A. W., L. M. Patterson and R. W. Armstrong. 1979. Trapping and coded-wire tagging of wild coho, chinook, and steelhead juveniles from the Cowichan-Kokosilah River system, 1976. Dept. of Fisheries and Oceans, Fisheries and Marine Serv., Vancouver, B. C., Canada. Tech. Rept. No. 850. 117 p.
- Bjornn, T. C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, instream flows, cover, and population density. Trans. Am. Fish. Soc., 100(3): 423-438.
- Bjornn, T. C. 1978. Survival, production and yield of trout and chinook salmon in the Lemhi River, Idaho. Final Report. Federal Aid Fish. Rest. Proj. F-49-R, Idaho Dept. Fish and Game. 57 p.
- Bjornn, T. C., Brusven, M. A., McInau, M. P., Milligan, J. H., Klamt, R. A., Chacho, E. and C. Schaye. 1977. Transport of granitic sediment in streams and its effects on insects and fish. Forest, Wildlife and Range Exp. Stn., Completion Report, Water Resource Res. Inst., Proj. B-036-IDA. University of Idaho, Moscow. 43 p.
- Burns, James W. 1971. The carrying capacity for juvenile salmonids in some northern California streams. California Fish and Game. Vol. 57(1):44-57.
- Bustard, D. R. and D. W. Narver. 1975a. Aspects of the winter ecology of juvenile coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri). J. Fish. Res. Bd. Canada 32(5): 667-680.
- Bustard, D. R. and D. W. Narver. 1975b. Preferences of juvenile coho salmon (Oncorhynchus kisutch) and cutthroat trout (Salmo clarki). relative to simulated alteration of winter habitat. J. Fish. Res. Bd. Canada 32(5): 681-687.
- Chapman, D. W. 1966. Food and space as regulators of salmonid populations in streams. Am. Nat. 100: 345-357.
- Chapman, D. W. and T. C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. p. 153-176. In T. G. Northcote (ed.), Symposium on Salmon and Trout in Streams. H. R. MacMillan Lectures in Fisheries, University of British Columbia, Vancouver.

- Cordone, A.J., and D.W. Kelley. 1961. The influences of inorganic sediment on the aquatic life of streams. California Fish and Game. 47(2):189-228.
- Corley, D.R., and L. Burmeister. 1979. Fishery habitat survey of the South Fork Salmon River - 1979. USDA Forest Service, Intermountain Region, Boise National Forest, Boise, Idaho. 90 p.
- Elser, A. A. 1968. Fish populations of a trout stream in relation to major habitat zones and channel alterations. Trans. Am. Fish. Soc. 97(4): 389-397.
- Everest, F. H. 1969. Habitat selection and spatial interaction of juvenile chinook salmon and steelhead trout in two Idaho streams. Ph.D. Dissertation, University of Idaho, Moscow. 77 p.
- Everest, F.H. and D.W. Chapman. 1972. Habitat selection and spatial interaction by juvenile chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada. Vol. 29(1):91-100.
- Greentree, W. J. and R. C. Aldrich. 1976. Evaluating stream trout habitat on large-scale aerial photographs. USDA Forest Service Research Paper PSW-123, Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 21 p.
- Hart, D. S. and M. A. Brusven. 1976. Comparison of benthic insect communities in six small Idaho batholith streams. Melandria 23: 1-18.
- Herrington, R. B. and D. K. Dunham. 1967. A technique for sampling general fish habitat characteristics of streams. USAD Forest Service Research Paper INT-41, Intermountain Forest and Range Experiment Station. Ogden, Utah. 12 p.
- Hynes, H.B.N. 1972. The Ecology of Running Waters. Univeristy of Toronto Press. 555 pp.
- Johnson, W. E. 1965. On mechanisms of self-regulation of population abundance in (Oncorhynchus nerka), Mitt. Inter. Verein. Theo. Angew. Limnol. 13: 66-87.
- Jones, A. Neville. 1975. A preliminary study of fish segregation in salmon spawning streams. Journal of Fish Biology. Vol. 7(1):95-104.
- Keating, J. F. 1958. Clearwater River Fisheries Investigation, II. Trout migration studies. Idaho Dept. of Fish and Game, Final Rept., Proj. F-15-R. 36 p.

- Kiilsgaard, T. H. 1947. Compiled geologic map of Latah, Idaho, and Clearwater counties. Idaho Bureau of Mines and Geology.
- Klamt, R. R. 1976. The effects of coarse granitic sediment on the distribution and abundance of salmonids in the central Idaho batholith. M.S. Thesis, Univ. of Idaho, Moscow. 85 p.
- LeCren, E. D. 1965. Some factors regulating the size of populations of freshwater fish. Mitt.Verein. Theor. Angew. Limnol. 13: 88-105.
- Lewis, Stephen L. 1967. Physical factors influencing fish populations in pools of a trout stream. Masters Thesis. Montana State University, Bozeman. 33 pp.
- Mabbott, L. Brent. 1982. Density and habitat of wild and introduced juvenile steelhead trout in the Lochsa River Drainage, Idaho. Masters Thesis. University of Idaho, Moscow. 93 pp.
- Mallet, J. 1974. Long range planning for salmon and steelhead in Idaho. Job Number 2. Inventory of salmon and steelhead resources, habitat, use, and demands. Idaho Department of Fish and Game. Job Performance Report F-58-R-1. Boise, Idaho. 212 p.
- Morrill, C. F. and T. C. Bjornn. 1972. Migration response of juvenile chinook salmon to substrate and temperatures. Idaho Water Resour. Res. Inst. Tech. Completion Rept., Proj. A-038-IDA, Moscow. 27 p.
- Murphy, L. W. and H. E. Metsker. 1962. Inventory of Idaho streams containing anadromous fish including recommendations for improving production of salmon and steelhead. Part 2. Clearwater River Drainage. Idaho Department of Fish and
- Platts, W. S. 1976. Validity of methodologies to document stream environments for evaluating fishery conditions. Proceedings of the Symposium and Specialists Conference, Instream Flow Needs. Vol. II: 67-84.
- Reingold, M. 1964. Movement of juvenile steelhead between tributary and mainstem streams. Proj. No. 1-000-07-segment 2. p. 12-16. In Fisheries studies in connection with Dworshak (Bruce's Eddy) Dam and reservoir. Idaho Dept. Fish and Game, Boise.
- Reiser, D. W. and T. C. Bjornn. 1979. Habitat requirements of anadromous salmonids. USDA Forest Service, Pacific Northwest Forest and Range Exp. Stn. 54 p.

- Scheaffer, R.L., W. Mendenhall, and L. Ott. 1979. Elementary survey sampling. Duxbury Press, North Scituate, Massachusetts.
- Simons, D. B., Li, R. M., Ward, T. J., Combs, S. T. and C. C. Baggs. 1981. Forest management impacts on snowmelt and rainfall sediment yield in mountain streams. Vol. 1 Project Report, Vol. 2 Users Manual. Civil Engineering Department Engineering Research Center, Colorado State University, Fort Collins Colorado. Draft Report.
- Tappel, P. D. 1982. A new method of relating spawning gravel size composition to salmonid embryo survival. Masters Thesis. University of Idaho, Moscow.
- Thurrow, R.F. and T.C. Bjornn. 1978. Response of cutthroat trout populations to the cessation of fishing in St. Joe River Tributaries. Bulletin No. 25 Forest, Wildlife and Range Experiment Station, Moscow, Idaho. 35 p.
- Vincient, Richard. 1971. River electrofishing and fish population estimates. The Progressive Fish-Culturist. Vol. 33(3):163-169.

APPENDIX A
"Habitat Parameters"

Table A-1. Mean lengths, widths, depths, and surface velocities ($\pm$ 95% confidence interval in parentheses) for Gospel Hump streams by stream section and habitat type.

Creek section	Date	Habitat type	Number of transects measured	Flow (cfs)	Mean length (m)	Mean width (m)	Mean depth ¹ (cm)	Mean Thalweg depth (cm)	Mean surface ft/sec	velocity ² m/sec
Trapper										
Section 2	7-7-79	Pool	5	9.5	6.58 (4.19)	3.70 (0.88)	20.6 (5.6)	31.2 (8.1)	0.90 (0.31)	0.274 (0.093)
	7-7-79	Riffle	1		4.57 -	3.58 -	13.9 -	20.0 -	1.71 -	0.52 -
	7-7-79	Run	1		7.39 -	2.62 -	12.2 -	27.0 -	2.17 -	0.660 -
	7-7-79	Pocket	8		14.89 (11.20)	3.82 (0.45)	13.8 (6.5)	27.5 (10.6)	1.32 (0.18)	0.402 (0.055)
Section 2	6-23-80	Pool	8	16.8	5.41 (2.53)	5.15 (0.49)	30.4 (3.1)	47.3 (5.7)	1.21 (0.30)	0.370 (0.091)
	6-23-80	Riffle	3		3.90 (1.61)	4.27 (1.51)	19.0 (3.1)	30.0 (11.4)	1.57 (0.62)	0.479 (0.194)
	6-23-80	Run	3		5.53 (4.26)	4.43 (0.99)	26.4 (4.9)	41.3 (1.4)	1.44 (0.69)	0.438 (0.213)
	6-23-80	Pocket	5		14.89 (11.20)	5.14 (0.89)	25.3 (6.7)	41.0 (15.8)	1.33 (0.55)	0.406 (0.167)
Section 3	6-20-80	Pool	7	16.8	8.64 (5.42)	3.33 (0.67)	29.0 (4.0)	44.6 (9.3)	1.29 (0.31)	0.395 (0.093)
	6-20-80	Riffle	3		5.83 (3.23)	4.03 (1.59)	21.0 (8.2)	30.7 (10.0)	1.75 (0.82)	0.535 (0.258)
	6-20-80	Run	5		8.42 (6.08)	2.54 (0.50)	24.8 (4.6)	44.0 (8.6)	1.83 (0.29)	0.559 (0.091)
	6-20-80	Pocket	3		12.27 (17.17)	4.10 (33.4)	25.4 (4.2)	41.0 (31.4)	1.82 (0.89)	0.555 (0.212)
Twentynile³										
Section 1	7-19-80	Pool	6	26.0	5.52 (1.62)	5.85 (0.83)	43.3 (2.1)	72.2 (12.0)	1.21 (0.19)	0.370 (0.044)
	7-19-80	Riffle	2		6.65 (0.63)	8.3 -	19.9 (7.2)	35.5 (82.7)	1.17 (2.61)	0.359 (0.782)
	7-19-80	Run	2		8.15 (1.91)	4.3 -	35.3 (26.1)	57.0 (12.6)	1.61 (3.41)	0.491 (1.051)
	7-19-80	Pocket	7		7.99 (2.35)	7.50 (2.61)	26.2 (3.7)	52.3 (12.1)	1.23 (0.47)	0.375 (0.167)
Section 2	7-14-80	Pool	10	26.0	16.53 (10.25)	7.48 (0.97)	49.0 (6.2)	68.1 (9.4)	0.91 (0.131)	0.276 (0.040)
	to	Riffle	5		10.75 (7.43)	8.20 (15.27)	18.4 (2.9)	28.4 (5.8)	1.96 (0.55)	0.98 (0.166)
	7-15-80	Run ⁴	14		12.38 (7.39)	6.73 (1.56)	28.8 (3.0)	47.3 (6.7)	1.39 (0.30)	0.424 (0.089)
		Pocket	0		-	-	-	-	-	-
Section 3	7-16-80	Pool	11	26.0	8.37 (2.79)	5.24 (0.69)	30.3 (3.8)	53.3 (7.3)	0.92 (0.12)	0.279 (0.038)
	to	Riffle	2		8.65 (29.83)	5.90 -	14.9 (18.9)	46.0 (126.7)	1.63 (5.48)	0.500 (1.671)
	7-29-80	Run	7		7.36 (3.41)	4.00 (0.58)	23.3 (5.1)	36.1 (4.0)	1.53 (0.42)	0.467 (0.128)
		Pocket	6		8.33 (1.65)	6.30 (1.89)	18.8 (4.9)	39.3 (4.5)	1.21 (0.17)	0.369 (0.051)
W. Fork Twentynile										
	7-18-80	Pool	7	5.0	5.91 (2.11)	3.08 (0.35)	17.4 (2.1)	29.0 (3.5)	0.83 (0.131)	0.253 (0.040)
	7-18-80	Riffle	4		5.95 (4.13)	2.63 (0.40)	11.4 (2.7)	14.5 (3.3)	1.25 (0.36)	0.379 (0.109)
	7-18-80	Run	3		5.00 (1.08)	2.67 (1.86)	15.6 (20.6)	26.3 (16.0)	0.79 (0.64)	0.239 (0.194)
	7-18-80	Pocket ⁵	1		5.60 -	3.90 -	10.9 -	25.0 -	0.87 -	0.266 -
Hill										
Section 1	7-6-79	Pool	3	40.7	6.46 (3.31)	5.38 (1.57)	26.7 (7.9)	46.0 (39.5)	2.03 (1.11)	0.618 (0.339)
	7-6-79	Riffle	7		4.85 (15.82)	6.70 (20.93)	16.7 (13.7)	46.0 (126.7)	2.52 (1.14)	0.768 (0.350)
	7-6-79	Run	1		9.75 -	4.93 -	24.2 -	51.0 -	2.30 -	0.701 -
	7-6-79	Pocket	6		14.34 (11.40)	6.70 (1.33)	23.8 (4.7)	50.0 (8.9)	1.69 (0.35)	0.515 (0.105)
W. Fork Red River										
Section 1	7-9-79	Pool	5	12.9	10.58 (6.40)	7.39 (2.51)	32.8 (15.8)	58.0 (18.9)	0.94 (0.48)	0.283 (0.143)
	7-9-79	Riffle	2		9.03 (30.18)	6.27 -	13.7 (3.1)	31.0 (76.3)	1.61 (3.59)	0.492 (1.105)
	7-9-79	Run	2		10.54 (10.93)	5.59 -	21.9 (9.5)	34.0 (50.9)	1.25 (2.09)	0.379 (0.638)
	7-9-79	Pocket	4		9.98 (7.65)	5.91 (1.35)	20.7 (2.0)	40.3 (14.1)	1.65 (0.29)	0.501 (0.089)
Section 1	6-26-80	Pool	4		10.58 (6.40)	7.37 (2.85)	39.4 (13.4)	56.3 (11.5)	1.47 (0.75)	0.448 (0.227)
	6-26-80	Riffle	2		9.03 (30.18)	7.40 -	23.6 (16.2)	29.5 (18.9)	1.76 (3.68)	0.537 (1.11)
	6-26-80	Run	2		10.54 (10.93)	6.60 -	32.6 (0.9)	48.5 (70.1)	1.39 (1.89)	0.429 (0.647)
	6-26-80	Pocket	4		9.98 (7.65)	6.90 (2.07)	28.9 (4.6)	43.5 (7.6)	1.63 (0.37)	0.497 (0.110)

Table A-1. (continued)

Creek section	Date	Habitat type	Number of transects measured	Flow (cfs)	Mean length (m)	Mean width (m)	Mean depth ¹ (cm)	Mean Thalweg depth (cm)	Mean surface ft/sec	velocity ² m/sec
Tennille										
Section 1	7-31-79	Pool	15		10.22 (2.22)	8.63 (1.27)	35.4 (5.5)	67.7 (8.92)	1.10 (0.23)	0.335 (0.066)
		to Riffle	5		8.12 (2.92)	11.05 (3.77)	18.2 (6.3)	33.8 (9.67)	1.12 (0.81)	0.342 (0.246)
	8-10-79	Run	4		10.25 (3.59)	7.07 (2.12)	24.1 (9.9)	42.7 (3.53)	1.69 (0.12)	0.515 (0.041)
		Pocket	10		8.55 (3.15)	10.70 (1.40)	19.4 (3.1)	39.6 (5.7)	1.43 (0.25)	0.435 (0.077)
Section 2	7-30-79	Pool	7		9.27 (2.68)	8.09 (1.86)	45.7 (5.4)	82.9 (13.8)	1.23 (0.33)	0.375 (0.098)
	7-30-79	Riffle	1		7.00 -	14.0 -	14.8 -	28.0 -	2.07 -	0.631 -
	7-30-79	Run	0		- -	- -	- -	- -	- -	- -
	7-30-79	Pocket	1		6.00 -	6.9 -	30.2 -	52.0 -	2.50 -	0.762 -
Section 3	7-28-79	Pool	5		12.76 (5.34)	8.63 (3.72)	35.6 (13.4)	54.6 (18.7)	1.36 (0.59)	0.415 (0.799)
		to Riffle	10		12.38 (3.99)	12.9 (2.2)	17.3 (3.7)	30.3 (5.5)	1.57 (0.23)	0.478 (0.070)
	7-30-79	Run	6		12.00 (2.57)	7.1 -	30.4 (6.3)	42.7 (7.1)	2.06 (0.35)	0.627 (0.108)
		Pocket	7		10.81 (3.28)	9.96 (1.66)	27.7 (5.9)	49.3 (9.3)	1.48 (0.42)	0.452 (0.129)
Section 4	7-26-79	Pool	9		9.97 (2.36)	7.73 (1.89)	39.0 (7.1)	64.8 (7.9)	1.29 (0.48)	0.395 (0.146)
		to Riffle	13		11.52 (1.90)	9.99 (1.84)	28.4 (3.4)	39.1 (5.8)	1.86 (0.29)	0.568 (0.088)
	7-27-79	Run	11		10.09 (3.13)	8.10 (1.11)	29.0 (4.2)	47.0 (6.3)	1.91 (0.34)	0.581 (0.104)
		Pocket	8		10.65 (3.48)	9.32 (2.31)	27.8 (6.0)	51.4 (4.5)	1.62 (0.26)	0.494 (0.079)
Johns										
(Pooled kilon 1-5)	8-15-79	Pool	22	49.0	10.82 (1.84)	11.23 (2.95)	46.3 (6.9)	82.1 (9.1)	1.20 (0.21)	0.366 (0.063)
		to Riffle	12	to	10.82 (2.66)	12.35 (6.29)	15.4 (4.5)	40.6 (7.1)	1.64 (0.46)	0.501 (0.141)
	9-5-79	Run	6	44.8	10.58 (4.60)	6.1 -	31.0 (4.6)	53.8 (12.9)	2.88 (0.94)	0.877 (0.289)
		Pocket	21		9.39 (1.33)	12.48 (1.22)	25.1 (2.5)	56.7 (8.8)	1.41 (0.20)	0.431 (0.061)

^{1/} Depth measurements of less than 0.5 cm were included in the mean depth calculations.

^{2/} Surface velocities were not measurable in water depth of less than 1.0 cm and were not included in mean surface velocity calculations.

^{3/} Pools in Twenty Mile Creek were cluster sampled at a rate one transect per 5.0 meters of pool length.

^{4/} Section 2 of Twenty Mile Creek contained several areas of split channels which divided the flow evenly. The widths for habitat types in this section do not include the split channel sites.

Table A-2. Percentages of each size class of substrate material, instream cover type, and overhead (bank) cover type for Gospel Hump streams by stream section and habitat type.

Cross section	Date	Habitat type	Number of transects measured	Substrate Percent of each size						Overhead cover Percent of each type					Instream cover Percent of each type				
				Silt	Sand	Fine gravel	Gravel	Cobble	Boulder or bedrock	None	Undercut bank	Overhang = 2m	2 m to overstory	Overstory	None	Aquatic vegetation	Logs, boulders or debris above	Logs, boulders or debris in water	
Trapper																			
Section 2	7-7-79	Pool	5	0	24	3	7	35	31	25	0	63	0	12	26	15	15	44	
	7-7-79	Riffle	1	0	7	22	7	50	14	0	0	100	0	0	86	0	0	14	
	7-7-79	Run	1	0	17	17	0	33	33	0	0	50	50	0	33	0	0	67	
	7-7-79	Pocket	8	0	10	15	18	21	36	50	13	31	6	0	31	0	16	53	
Section 2	6-23-80	Pool	8	4	14	7	16	37	22	6	0	73	6	13	36	1	18	45	
	6-23-80	Riffle	3	2	2	2	19	40	35	0	17	83	0	0	53	0	24	23	
	6-23-80	Run	3	2	14	14	20	38	12	17	0	83	0	0	40	0	12	48	
	6-23-80	Pocket	5	5	6	5	27	31	26	10	0	70	0	20	31	0	16	53	
Section 3	6-20-80	Pool	7	0	17	27	42	7	7	23	54	23	0	0	47	22	7	24	
	6-20-80	Riffle	3	0	11	25	54	10	0	17	33	50	0	0	26	41	11	22	
	6-20-80	Run	5	0	15	2	66	15	2	40	50	10	0	0	50	42	0	8	
	6-20-80	Pocket	3	0	17	26	50	7	0	17	50	33	0	0	46	39	0	15	
Twentymile																			
Section 1	7-19-80	Pool	6	1	23	6	10	19	41	17	9	74	0	0	26	3	16	55	
	7-19-80	Riffle	2	0	14	18	29	23	16	33	0	67	0	0	42	8	8	42	
	7-19-80	Run	2	0	0	0	11	16	73	0	0	100	0	0	72	7	0	21	
	7-19-80	Pocket	7	0	20	5	14	22	39	40	20	30	10	0	36	10	1	53	
Section 2	7-14-80	Pool	10	7	45	20	22	6	0	24	4	66	2	4	34	33	12	21	
	to	Riffle	5	5	21	15	48	9	2	50	10	40	0	0	30	48	12	10	
	7-15-80	Run ⁴	14	2	45	13	32	7	1	25	11	61	0	3	24	47	8	21	
		Pocket	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Section 3	7-16-80	Pool	11	1	28	8	19	20	24	29	7	58	2	4	29	10	21	40	
	to	Riffle	2	0	3	8	39	33	17	20	0	60	0	20	30	15	10	45	
	7-29-80	Run	7	0	19	1	30	25	25	46	0	54	0	0	27	10	13	50	
		Pocket	6	0	15	11	15	28	31	0	11	67	11	11	33	3	25	39	
W. Fork Twentymile																			
	7-18-80	Pool	7	1	37	34	25	3	0	33	0	54	0	13	29	23	16	32	
	7-18-80	Riffle	4	0	13	40	35	12	0	25	0	50	25	0	39	22	16	23	
	7-18-80	Run	3	2	62	21	3	0	12	17	0	66	17	0	53	40	0	7	
	7-18-80	Pocket	1	0	60	40	0	0	0	0	50	50	0	0	4	27	38	31	
Hill																			
Section 1	7-6-79	Pool	3	7	3	0	20	43	27	17	16	50	0	17	39	0	13	48	
	7-6-79	Riffle	2	5	2	7	0	27	59	25	0	25	0	50	24	0	24	52	
	7-6-79	Run	1	0	0	0	14	43	43	50	0	50	0	0	72	0	14	14	
	7-6-79	Pocket	6	3	4	5	26	36	26	34	8	33	17	8	41	2	9	48	

Table A-2. (continued)

Creek Station	Date	Habitat type	Number of transects measured	Substrate Percent of each size						Overhead cover Percent of each type					Instream cover Percent of each type				
				Silt	Sand	Pea gravel	Gravel	Cobble	Boulder or bedrock	None	Undercut bank	Overhang = 2 m	2 m to overstory	Overstory	None	Aquatic vegetation	Logs, boulders or debris above	Logs, boulders or debris in water	
W. Ford Red River																			
Section 1	7-9-79	Pool	5	23	28	11	6	16	16	20	0	80	0	0	22	7	21	50	
	7-9-79	Riffle	2	12	10	12	21	26	19	33	0	67	0	0	39	0	17	44	
	7-9-79	Run	2	9	19	12	19	22	19	67	0	0	0	33	4	0	46	50	
	7-9-79	Pocket	4	0	18	6	12	30	34	25	12	63	0	0	8	2	22	68	
Section 1	6-26-80	Pool	4	2	31	6	16	19	26	25	12	63	0	0	56	7	9	28	
	6-26-80	Riffle	2	0	9	3	34	48	6	33	0	67	0	0	89	0	5	6	
	6-26-80	Run	2	3	38	0	12	25	22	0	0	100	0	0	50	12	25	13	
	6-26-80	Pocket	4	2	20	8	15	29	26	12	13	75	0	0	59	10	2	29	
Tennile																			
Section 1	7-31-79	Pool	15	0	12	7	14	19	48	59	0	24	7	10	43	1	8	48	
		to Riffle	5	1	11	6	29	38	15	40	10	30	10	10	59	4	2	35	
	8-10-79	Run	4	0	7	2	18	36	36	83	0	0	17	0	70	4	4	22	
		Pocket	10	0	5	6	13	26	50	58	0	32	0	10	42	3	11	44	
Section 2	7-30-79	Pool	7	1	18	3	8	14	56	79	0	21	0	0	23	3	12	62	
	7-30-79	Riffle	1	4	0	4	8	19	65	50	0	50	0	0	57	0	7	36	
	7-30-79	Run	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	7-30-79	Pocket	1	0	0	8	8	34	50	50	0	50	0	0	50	0	0	50	
Section 3	7-28-79	Pool	5	1	24	15	19	25	15	20	0	60	20	0	44	2	12	42	
		to Riffle	10	0	8	8	34	33	17	50	0	31	13	6	51	2	4	43	
	7-30-79	Run	6	0	11	7	20	41	20	38	0	25	25	12	42	6	18	33	
		Pocket	7	0	13	8	13	29	37	59	0	25	8	8	37	0	5	58	
Section 4	7-26-79	Pool	9	0	18	9	13	25	35	44	6	50	0	0	22	4	18	56	
		to Riffle	13	0	7	7	23	30	33	38	0	38	10	14	36	1	6	57	
	7-27-79	Run	11	1	7	10	18	27	37	60	0	15	5	20	49	4	7	40	
		Pocket	8	2	6	10	14	20	48	19	0	69	6	6	26	5	9	60	
Johns																			
(Pooled kilon	8-15-79	Pool	22	0	4	2	10	27	57	82	0	7	7	4	35	2	6	57	
		to Riffle	12	1	1	3	15	36	44	88	0	0	12	0	48	1	1	50	
	9-5-79	Run	6	0	2	0	10	35	53	100	0	0	0	0	52	0	0	48	
		Pocket	21	0	3	3	7	25	62	73	0	6	16	5	38	0	7	55	

APPENDIX B
"Species Composition"

Table B-1. Species composition by section and habitat type in Johns Creek, 1979 and 1980.

Creek-Year					
Section	Chinook	Rainbow/	Cutthroat	Full	Whitefish
Habitat	salmon	steelhead	trout	trout	
Johns-1979					
Section 1					
Pools	4.8	89.8	1.8	1.2	2.4
Riffles	0	94.1	0	2.9	2.9
Runs	0	95.2	2.4	2.4	0
Pocketwaters	0.5	94.2	2.1	0	3.1
Backwaters	0	100.0	0	0	0
Side channels	0	100.0	0	0	0
Combined	1.5	94.5	1.4	1.1	1.4
Johns-1981					
Section 1					
Pools	0	96.1	0.3	0.7	2.9
Riffles	0	90.0	0	0	10.0
Runs	0	98.6	0	1.4	0
Pocketwaters	0	94.8	0	1.0	4.2
Combined	0	96.2	0.1	1.0	2.7

Table B-2. Species composition by section and habitat type in Tenmile Creek, 1979 and 1981.

Creek-Year Section Habitat	Chinook salmon	Rainbow/ steelhead	Cutthroat trout	Bull trout	Whitefish
Tenmile-1979					
Section 1					
Pools	46.0	48.0	1.3	1.3	3.4
Riffles	28.7	66.7	0	0	4.6
Runs	4.3	82.8	8.6	0	4.3
Pocketwaters	18.2	75.9	2.2	1.5	2.2
Backwaters	91.3	8.7	0	0	0
Side channels	33.2	66.8	0	0	0
Combined	58.9	38.4	0.9	0.4	1.4
Section 2					
Pools	43.3	52.8	1.3	1.3	1.3
Riffles	0	100.0	0	0	0
Runs	0	0	0	0	0
Pocketwaters	44.4	55.6	0	0	0
Backwaters	0	0	0	0	0
Side channels	0	0	0	0	0
Combined	36.9	60.6	0.8	0.8	0.8
Section 3					
Pools	60.9	35.5	0	3.3	0.4
Riffles	50.8	45.3	0	3.1	0.8
Runs	40.4	54.5	1.7	3.4	0
Pocketwaters	47.2	50.2	0.9	0.9	0.9
Backwaters	100.0	0	0	0	0
Side channels	42.8	42.8	0	14.4	0
Combined	88.3	10.3	0.1	1.1	0.1
Section 4					
Pools	1.4	63.6	30.4	3.7	0.9
Riffles	0	88.6	4.5	4.5	2.3
Runs	2.5	92.5	2.5	2.5	0
Pocketwaters	1.4	90.3	6.9	1.4	0
Backwaters	27.2	54.4	18.4	0	0
Side channels	0	100.0	0	0	0
Combined	7.1	73.8	16.5	2.1	0.5

Table B-2. Tenmile Creek continued.

Tenmile-1979					
Sections 1-4					
Pools	87.0	9.3	1.9	1.2	0.5
Riffles	27.0	68.7	0.6	1.7	2.0
Runs	22.2	70.7	3.7	2.3	1.1
Pocketwaters	33.5	62.9	1.8	0.9	0.9
Backwaters	96.6	2.9	0.5	0	0
Side channels	33.5	60.3	0	6.2	0
Combined	72.7	24.2	1.6	1.0	0.4
Tenmile-1981					
Section 1					
Pools	0	75.5	1.4	2.0	21.1
Riffles	0	92.0	0	2.3	5.7
Runs	0	100.0	0	0	0
Pocketwaters	0	93.5	0	0	6.5
Combined	0	87.7	0.5	1.3	10.6
Section 2					
Pools	0	87.4	2.3	2.3	8.0
Riffles	0	100.0	0	0	0
Runs	0	0	0	0	0
Pocketwaters	0	71.4	28.6	0	0
Combined	0	86.2	8.4	1.2	4.2
Section 3					
Pools	0	92.6	0	6.3	1.1
Riffles	0	85.4	6.3	8.3	0
Runs	0	96.4	0	0	3.6
Pocketwaters	0	96.8	1.6	1.6	0
Combined	0	97.0	1.4	3.4	1.1
Section 4					
Pools	0	89.9	7.6	1.3	1.3
Riffles	0	85.0	7.5	5.0	2.5
Runs	0	96.3	0	3.7	0
Pocketwaters	0	85.7	10.7	3.6	0
Combined	0	89.5	6.6	3.1	0.9

Table B-2. Tenmile Creek continued.

Tenmile-1981					
Sections 1-4					
Pocls	0	85.3	2.4	2.8	9.5
Riffles	0	92.4	2.4	3.2	2.0
Runs	0	97.6	0	1.0	1.4
Pocketwaters	0	88.2	9.0	1.1	1.7
Combined	0	89.3	3.8	2.1	4.7

Table B-3. Species composition by section and habitat type in Twentymile Creek, 1980 and 1981.

Creek-Year					
Section	Chinook	Rainbow/	Cutthroat	Full	Whitefish
Habitat	salmon	steelhead	trout	trout	
Section 1					
Pools	0	8.6	91.4	0	0
Riffles	0	0	100.0	0	0
Runs	0	0	100.0	0	0
Pocketwater	0	20.5	79.5	0	0
Backwaters	0	0	100.0	0	0
Side channels	0	0	0	0	0
Combined	0	6.8	93.2	0	0
Section 2					
Pools	0	32.9	67.1	0	0
Riffles	0	36.4	63.6	0	0
Runs	0	34.2	65.8	0	0
Pocketwater	0	0	0	0	0
Backwaters	0	0	0	0	0
Side channels	0	20.4	79.6	0	0
Combined	0	29.6	70.4	0	0
Section 3					
Pools	0	9.2	90.8	0	0
Riffles	0	25.5	74.5	0	0
Runs	0	16.9	83.1	0	0
Pocketwater	0	0	100.0	0	0
Backwaters	0	16.6	83.4	0	0
Side channels	0	20.0	80.0	0	0
Combined	0	15.1	84.9	0	0
Sections 1-3					
Pools	0	14.4	85.6	0	0
Riffles	0	19.3	80.7	0	0
Runs	0	16.0	84.0	0	0
Pocketwater	0	11.2	88.8	0	0
Backwaters	0	14.1	85.9	0	0
Side channels	0	20.2	79.8	0	0
Combined	0	15.1	84.9	0	0

Table B-3. Tenmile Creek continued.

West Fork of Twentymile-1980					
Sections 4					
Pools	0	9.0	91.0	0	0
Riffles	0	0	100.0	0	0
Runs	0	0	100.0	0	0
Pocketwater	0	0	100.0	0	0
Backwaters	0	0	100.0	0	0
Side channels	0	0	0	0	0
Combined	0	2.3	97.7	0	0
Twentymile-1981					
Section 2					
Pools	0	0	100.0	0	0
Riffles	0	0	100.0	0	0
Runs	0	0	100.0	0	0
Pocketwater	0	0	0	0	0
Combined	0	0	100.0	0	0
Section 3					
Pools	0	0	100.0	0	0
Riffles	0	0	100.0	0	0
Runs	0	2.3	97.7	0	0
Pocketwater	0	0	100.0	0	0
Combined	0	0.7	99.3	0	0
Sections 2-3					
Pools	0	0	100.0	0	0
Riffles	0	0	100.0	0	0
Runs	0	2.1	97.9	0	0
Pocketwater	0	0	100.0	0	0
Combined	0	0.7	99.3	0	0

Table B-4. Species composition by section and habitat type in Mill Creek and West Fork of Red River, 1979 and 1980.

Creek-Year Section Habitat	Chinook salmon	Rainbow/ steelhead	Cutthroat trout	Bull trout	Whitefish
Mill-1979					
Section 1					
Pools	0	100.0	0	0	0
Riffles	0	0	0	0	0
Runs	0	100.0	0	0	0
Pocketwater	0	100.0	0	0	0
Combined	0	100.0	0	0	0
Mill-1780					
Section 1					
Pools	0	97.1	2.9	0	0
Riffles	0	100.0	0	0	0
Runs	0	100.0	0	0	0
Pocketwater	0	98.9	1.1	0	0
Combined	0	98.8	1.2	0	0
West Fork of Red River-1979					
Section 1					
Pools	0	5.8	66.9	17.3	10.1
Riffles	0	100.0	0	0	0
Runs	0	11.3	77.5	11.3	0
Pocketwater	0	17.4	65.2	8.7	8.7
Combined	0	8.2	73.7	12.2	5.9
West Fork of Red River-1980					
Section 1					
Pools	0	46.6	44.1	2.5	6.8
Riffles	0	100.0	0	0	0
Runs	0	50.0	50.0	0	0
Pocketwater	0	54.8	40.5	0	4.8
Combined	0	52.0	43.3	0.9	3.7

Table B-5. Species composition by section and habitat type in Trapper Creek, 1979, 1980 and 1981.

Creek-Year Section Habitat	Chinook salmon	Rainbow/ steelhead	Cutthroat trout	Bull trout	Whitefish
Trapper-1979.					
Section 2					
Pools	0	16.7	83.3	0	0
Riffles	0	0	100.0	0	0
Runs	0	0	100.0	0	0
Pocketwater	0	0	100.0	0	0
Combined	0	6.8	93.2	0	0
Trapper-1980					
Section 2					
Pools	0	10.2	89.8	0	0
Riffles	0	25.2	74.8	0	0
Runs	0	10.9	89.1	0	0
Pocketwater	0	13.6	86.4	0	0
Combined	0	15.5	84.5	0	0
Section 3					
Pools	0	9.3	87.3	3.4	0
Riffles	0	0	100.0	0	0
Runs	0	6.5	93.5	0	0
Pocketwater	0	9.0	91.0	0	0
Combined	0	7.1	91.8	1.1	0
Trapper-1981					
Section 2					
Pools	0	0	100.0	0	0
Riffles	0	0	0	0	0
Runs	0	0	100.0	0	0
Pocketwater	0	0	100.0	0	0
Combined	0	0	100.0	0	0
Section 3					
Pools	0	0	100.0	0	0
Riffles	0	0	100.0	0	0
Runs	0	0	100.0	0	0
Pocketwater	0	0	100.0	0	0
Combined	0	0	100.0	0	0

APPENDIX C
"Mean Fish Densities"

Table C-9. Mean fish densities (fish/100m²) by species and length class in Johns Creek (1979 and 1981) by species, length class, section, and habitat type (+ 95% confidence interval for densities in parentheses).

Creek-Year Section Date	n	Trout								Whitefish			Chinook salmon		Total		
		Fry		Rb/Sh		Cutthroat		Bull		0-51 (mm)	51-150 (mm)	150+ (mm)	Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50	51-150	150+	51-150	150+	51-150	150+									
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)									
Johns-1979																	
Section 1																	
Pools	21	12.0 (2.8)	8.3 (1.6)	6.7 (1.4)	0.1 (0.1)	0.2 (0.2)	0 (-)	0.2 (0.2)	0 (-)	0 (-)	0.4 (0.4)	0 (-)	0.8 (1.0)	12.0 (2.8)	9.2 (1.9)	7.4 (1.6)	
Riffles	14	9.5 (2.8)	2.4 (0.6)	0.8 (0.4)	0 (-)	0 (-)	0 (-)	0.1 (0.2)	0 (-)	0 (-)	0.1 (0.2)	0 (-)	0 (-)	9.5 (2.8)	2.4 (0.6)	1.1 (0.5)	
Runs	6	15.6 (7.6)	6.9 (1.7)	5.1 (2.9)	0.3 (0.7)	0 (-)	0 (-)	0.3 (0.6)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	15.6 (7.6)	7.2 (1.6)	5.4 (3.5)	
Pocket- waters	19	9.3 (2.1)	5.4 (1.9)	3.6 (1.1)	0.1 (0.2)	0.1 (0.1)	0 (-)	0 (-)	0 (-)	0 (-)	0.3 (0.4)	0 (-)	0.05 (0.1)	9.3 (2.1)	5.6 (2.0)	3.9 (1.0)	
Back- waters	6	48.5 (29.6)	4.0 (4.0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	48.5 (29.6)	4.0 (4.0)	0 (-)	
Side channels	3	53.5 (33.2)	8.5 (1.5)	0.8 (4.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	53.5 (33.2)	8.5 (1.5)	0.8 (4.4)	
Johns-1981																	
Section 1																	
Pools	18	1.8 (1.0)	7.0 (2.0)	6.3 (1.5)	0.04 (0.1)	0 (-)	0 (-)	0.1 (0.1)	0 (-)	0 (-)	0.4 (0.4)	0 (-)	0 (-)	1.8 (1.0)	7.1 (2.0)	6.8 (1.6)	
Riffles	8	2.0 (1.7)	1.9 (1.5)	0.8 (0.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.3 (0.3)	0 (-)	0 (-)	2.0 (1.7)	1.9 (1.5)	1.1 (0.6)	
Runs	6	3.6 (5.0)	9.7 (4.7)	4.7 (4.2)	0 (-)	0 (-)	0.2 (0.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	3.6 (5.0)	9.9 (5.0)	4.7 (4.2)	
Pocket- waters	16	0.9 (0.5)	5.9 (2.3)	3.2 (0.8)	0 (0.1)	0 (-)	0.05 (0.1)	0.05 (0.1)	0 (-)	0 (-)	0.4 (0.5)	0 (-)	0 (-)	0.9 (0.5)	6.1 (2.4)	3.7 (1.0)	

Table C-2. Mean fish densities (fish/100m²) by species and length class in Tenmile Creek (1979 and 1981) by species, length class, section, and habitat type (* 95% confidence interval for densities in parentheses).

Creek-Year Section Date	n	Trout								Whitefish			Chinook salmon		Total		
		Pry	Bb/Sh		Cutthroat		Bull		Age 0				Age I				
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)			0-50 (mm)	51-150+ (mm)	150+ (mm)	
Tenmile-1979																	
Section 1																	
Pools	12	3.9 (1.9)	10.7 (2.9)	3.6 (1.2)	0.4 (0.5)	0 (-)	0 (-)	0.4 (0.3)	0 (-)	0 (-)	1.0 (0.6)	13.2 (13.2)	0.5 (0.8)	17.1 (12.0)	11.6 (3.3)	5.0 (1.5)	
Riffles	6	9.7 (2.5)	6.4 (2.5)	0.8 (0.8)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.5 (0.8)	3.1 (4.3)	0 (-)	12.8 (4.6)	6.4 (2.5)	1.3 (1.6)	
Runs	4	4.8 (5.3)	7.7 (5.0)	0 (-)	0.4 (1.2)	0.4 (1.0)	0 (-)	0 (-)	0 (-)	0 (-)	0.4 (1.3)	0.4 (1.2)	0 (-)	5.3 (6.1)	8.1 (4.2)	0.8 (1.3)	
Pocket- waters	8	6.4 (7.4)	8.7 (2.0)	1.7 (0.8)	0 (-)	0.3 (0.4)	0 (-)	0.3 (-)	0 (-)	0 (-)	0.3 (0.4)	2.3 (1.2)	0.2 (0.3)	8.7 (8.4)	8.8 (2.1)	2.4 (1.0)	
Back- waters	5	50.6 (76.2)	6.3 (8.1)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	66.5 (33.7)	0.0 (-)	117.1 (75.1)	6.3 (8.1)	0 (-)	
Side channels	1	(45.8) (-)	(15.3) (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.0 (-)	0.0 (-)	7.6 (-)	0.0 (-)	53.4 (-)	15.3 (-)	0 (-)	
Section 2																	
Pools	7	1.0 (2.2)	13.3 (4.2)	2.9 (1.8)	0.4 (0.6)	0 (-)	0 (-)	0.4 (0.5)	0 (-)	0 (-)	0.4 (0.5)	13.3 (5.5)	0 (-)	12.9 (7.2)	15.2 (5.8)	3.7 (2.4)	
Riffles	1	2.5 (-)	5.0 (-)	2.5 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.5 (-)	5.0 (-)	2.5 (-)	
Runs	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	
Pocket- waters	1	1.2 (-)	6.0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	4.8 (-)	0 (-)	6.0 (-)	5.0 (-)	0 (-)	
Back- waters	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	
Side channels	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	

Table C-2. Tensile Creek continued.

Creek-Year Section Date	n	Trout								Whitefish			Chinook salmon		Total		
		Fry	Rb/Sh		Cutthroat		Bull										
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)	Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)	
Section 3																	
Pools	5	1.7 (3.1)	12.6 (8.4)	3.3 (1.8)	0 (-)	0 (-)	0.2 (0.6)	1.3 (1.6)	0 (-)	0 (-)	0.2 (0.5)	27.2 (15.4)	0.2 (0.5)	28.9 (16.1)	13.0 (8.5)	4.8 (2.5)	
Riffles	10	1.0 (0.8)	5.7 (2.0)	0.1 (0.2)	0 (-)	0 (-)	0.1 (0.1)	0.3 (0.3)	0 (-)	0 (-)	0.1 (0.2)	6.5 (3.9)	0 (-)	7.6 (4.4)	5.7 (1.9)	0.5 (0.3)	
Runs	6	1.1 (2.0)	8.3 (5.6)	1.4 (1.4)	0.3 (0.7)	0 (-)	0 (-)	0.6 (1.0)	0 (-)	0 (-)	0 (-)	7.2 (3.8)	0 (-)	8.3 (4.2)	8.6 (5.3)	2.0 (1.6)	
Pocket- waters	7	1.9 (1.8)	9.4 (3.7)	2.3 (2.1)	0 (-)	0.2 (0.3)	0 (-)	0.2 (0.4)	0 (-)	0 (-)	0.2 (0.3)	11.0 (2.9)	0 (-)	12.8 (4.0)	9.4 (3.7)	2.8 (2.3)	
Back- waters	1	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	386.7 (-)	0 (-)	386.7 (-)	0 (-)	0 (-)	
Side channels	1	3.1 (-)	9.2 (-)	0 (-)	0 (-)	0 (-)	0 (-)	3.1 (-)	0 (-)	0 (-)	0 (-)	9.2 (-)	0 (-)	9.2 (-)	9.2 (-)	3.1 (-)	
Section 4																	
Pools	9	0 (-)	10.1 (2.7)	3.7 (1.8)	6.4 (0.8)	0.2 (0.3)	0.2 (0.4)	0.6 (0.5)	0 (-)	0 (-)	0.2 (0.3)	0 (-)	0.3 (0.4)	0 (-)	11.3 (3.2)	4.7 (2.1)	
Riffles	13	0.3 (0.4)	3.5 (0.6)	0.4 (0.4)	0.2 (0.2)	0 (-)	0.1 (0.2)	0.1 (0.1)	0 (-)	0 (-)	0.1 (0.2)	0 (-)	0 (-)	0.3 (0.4)	3.8 (0.6)	0.6 (0.4)	
Runs	9	0.3 (0.7)	5.9 (2.3)	1.5 (1.7)	0 (-)	0.2 (0.4)	0 (-)	0.2 (0.4)	0 (-)	0 (-)	0 (-)	0 (-)	0.2 (0.3)	0.3 (0.7)	6.1 (2.5)	1.9 (1.7)	
Pocket- waters	8	1.0 (1.4)	5.6 (1.9)	0.9 (0.5)	0.5 (0.9)	0 (-)	0 (-)	0.1 (0.2)	0 (-)	0 (-)	0 (-)	0 (-)	0.1 (0.3)	1.0 (1.4)	6.2 (1.9)	1.0 (0.7)	
Back- water	2	2.5 (25.9)	7.4 (38.5)	0 (-)	2.5 (32.2)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	3.7 (9.8)	2.5 (25.9)	13.5 (61.0)	0 (-)	
Side channels	2	0 (-)	5.7 (10.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	5.7 (10.4)	0 (-)	

Table C-2. Tenmile Creek continued.

Creek-Year Section Date		Trout								Whitefish			Chinook salmon		Total		
		Fry	Rb/Sb		Cutthroat		Bull		Age 0				Age I				
		n	0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)			0-50 (mm)	51-150+ (mm)	150+ (mm)
Tenmile-1981																	
Section 1																	
Pools	10	0 (-)	5.2 (1.8)	5.9 (2.9)	0 (-)	0.2 (0.4)	0.1 (0.3)	0.2 (0.3)	0 (-)	0.6 (1.2)	2.5 (2.8)	0 (-)	0 (-)	0 (-)	5.9 (2.3)	9.0 (5.2)	
Riffles	5	0 (-)	6.4 (3.5)	1.6 (1.4)	0 (-)	0 (-)	0 (-)	0.2 (0.5)	0 (-)	0.5 (0.8)	0 (-)	0 (-)	0 (-)	0 (-)	6.9 (3.7)	1.8 (1.4)	
Runs	3	0 (-)	5.5 (9.7)	1.5 (2.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	5.5 (9.7)	1.5 (2.4)	
Pocket- waters	8	0 (-)	5.4 (1.8)	3.3 (1.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.6 (1.2)	0 (-)	0 (-)	0 (-)	5.4 (1.8)	3.8 (1.9)	
Section 2																	
Pools	7	1.9 (2.2)	8.3 (4.1)	6.9 (4.8)	0.2 (0.5)	0.2 (0.5)	0.2 (0.4)	0.2 (0.5)	0 (-)	0.2 (0.4)	1.2 (2.2)	0 (-)	0 (-)	1.9 (2.2)	8.9 (3.6)	8.5 (6.8)	
Riffles	1	2.5 (-)	7.5 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.5 (-)	7.5 (-)	0 (-)	
Runs	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	
Pocket- waters	1	2.4 (-)	3.6 (-)	2.4 (-)	0 (-)	2.4 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.4 (-)	3.6 (-)	4.8 (-)	
Section 3																	
Pools	5	0 (-)	3.2 (1.8)	5.6 (2.2)	0 (-)	0 (-)	0 (-)	0.6 (0.7)	0 (-)	0 (-)	0.1 (0.4)	0 (-)	0 (-)	0 (-)	3.2 (1.8)	6.3 (1.9)	
Riffles	8	0 (-)	2.4 (1.2)	1.7 (1.3)	0.1 (0.2)	0.2 (0.3)	0 (-)	0.4 (0.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.5 (1.1)	2.3 (1.5)	
Runs	3	0.3 (1.1)	3.5 (6.6)	4.6 (8.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.3 (1.1)	0 (-)	0 (-)	0.3 (1.1)	3.5 (6.6)	4.9 (8.5)	
Pocket- waters	5	0 (-)	5.4 (2.8)	6.6 (2.8)	0 (-)	0.2 (0.5)	0 (-)	0.2 (0.6)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	5.4 (2.8)	7.1 (3.0)	

Table C-2. Tensile Creek continued.

Creek-Year Section Date	n	Trout									Chinook salmon		Total				
		Fry		Rb/Sh		Cutthroat		Bull		Whitefish			Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50	51-150	150+	51-150	150+	51-150	150+	0-51	51-150	150+						
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)						
Section 4																	
Pools	9	0.1 (0.3)	4.7 (2.0)	2.4 (0.8)	0.5 (0.4)	0.1 (0.3)	0 (-)	0.1 (0.3)	0 (-)	0 (-)	0.1 (0.3)	0 (-)	0 (-)	0.1 (0.3)	5.2 (2.3)	2.8 (0.9)	
Riffles	13	0.2 (0.3)	3.1 (1.1)	0.3 (0.3)	0.2 (0.3)	0.1 (0.2)	0.1 (0.1)	0.1 (0.1)	0 (-)	0 (-)	0.1 (0.2)	0 (-)	0 (-)	0.2 (0.3)	3.4 (1.0)	0.6 (0.3)	
Runs	5	0.5 (0.6)	5.0 (2.3)	0.2 (0.7)	0 (-)	0 (-)	0.2 (0.6)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.5 (0.6)	5.3 (2.9)	0.2 (0.7)	
Pocket- waters	8	0.2 (0.3)	3.8 (2.1)	1.0 (0.8)	0.6 (0.7)	0 (-)	0.1 (0.3)	0.1 (0.3)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.2 (0.3)	4.6 (3.0)	1.1 (0.8)	

Table C-3 Mean fish densities (fish/100m²) by species and length class in Twentymile Creek (1980 and 1981) by species, length class, section, and habitat type (+ 95% confidence interval for densities in parentheses).

Creek-Year Section Date	n	Trout								Whitefish			Chinook salmon		Total		
		Fry		Rb/Sh		Cutthroat		Bull		0-51 (mm)	51-150 (mm)	150+ (mm)	Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)									
Twentymile-1980																	
Section 1																	
Pools	6	2.0 (2.1)	1.5 (2.8)	1.0 (1.3)	22.9 (14.1)	3.6 (2.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.0 (2.1)	24.4 (14.0)	4.6 (3.1)	
Riffles	2	0 (-)	0 (-)	0 (-)	2.5 (7.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (0)	2.5 (7.9)	0 (-)	
Runs	2	0 (-)	0 (-)	0 (-)	9.5 (39.8)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	9.5 (39.8)	0 (-)	
Pocket- water	7	0 (-)	1.6 (1.6)	0 (-)	5.4 (1.7)	0.8 (1.7)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	7.0 (1.3)	0.8 (1.7)	
Back- waters	2	11.2 (143.9)	0 (-)	0 (-)	11.2 (143.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	11.2 (143.9)	11.2 (143.9)	0 (-)	
Side channels	1	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	
Section 2																	
Pools	10	0.9 (0.5)	3.8 (1.2)	1.0 (0.5)	8.3 (1.6)	1.5 (0.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.9 (0.5)	12.1 (2.2)	2.5 (1.2)	
Riffles	4	0 (-)	0.4 (1.2)	0 (-)	0.7 (1.5)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1.1 (2.4)	0 (-)	
Runs	13	1.0 (0.9)	2.4 (1.0)	0.3 (0.4)	4.9 (1.3)	0.3 (0.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1.0 (0.9)	7.3 (1.6)	0.6 (0.7)	
Pocket- waters	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	
Back- waters	3	4.3 (20.7)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	4.3 (20.7)	0 (-)	0 (-)	
Side channels	2	2.0 (22.0)	2.0 (22.0)	0 (-)	7.8 (40.0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.0 (22.0)	9.8 (62.0)	0 (-)	

Table C-2. Tenaile Creek continued.

Creek-Year Section Date	n	Trout								Whitefish			Chinook salmon		Total		
		Fry	Rb/Sh		Cutthroat		Bull		Age 0				Age I				
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)	0	I	0-50 (mm)	51-150+ (mm)	150+ (mm)	
Tenaile-1981																	
Section 1																	
Pools	10	0 (-)	5.2 (1.8)	5.9 (2.9)	0 (-)	0.2 (0.4)	0.1 (0.3)	0.2 (0.3)	0 (-)	0.6 (1.2)	2.5 (2.8)	0 (-)	0 (-)	0 (-)	5.9 (2.3)	9.0 (5.2)	
Riffles	5	0 (-)	6.4 (3.5)	1.6 (1.4)	0 (-)	0 (-)	0 (-)	0.2 (0.5)	0 (-)	0.5 (0.8)	0 (-)	0 (-)	0 (-)	0 (-)	6.9 (3.7)	1.8 (1.4)	
Runs	3	0 (-)	5.5 (9.7)	1.5 (2.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	5.5 (9.7)	1.5 (2.4)	
Pocket- waters	8	0 (-)	5.4 (1.8)	3.3 (1.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.6 (1.2)	0 (-)	0 (-)	0 (-)	5.4 (1.8)	3.8 (1.9)	
Section 2																	
Pools	7	1.9 (2.2)	8.3 (4.1)	6.9 (4.8)	0.2 (0.5)	0.2 (0.5)	0.2 (0.4)	0.2 (0.5)	0 (-)	0.2 (0.4)	1.2 (2.2)	0 (-)	0 (-)	1.9 (2.2)	8.9 (3.6)	8.5 (6.8)	
Riffles	1	2.5 (-)	7.5 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.5 (-)	7.5 (-)	0 (-)	
Runs	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	
Pocket- waters	1	2.4 (-)	3.6 (-)	2.4 (-)	0 (-)	2.4 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.4 (-)	3.6 (-)	4.8 (-)	
Section 3																	
Pools	5	0 (-)	3.2 (1.8)	5.6 (2.2)	0 (-)	0 (-)	0 (-)	0.6 (0.7)	0 (-)	0 (-)	0.1 (0.4)	0 (-)	0 (-)	0 (-)	3.2 (1.8)	6.3 (1.9)	
Riffles	8	0 (-)	2.4 (1.2)	1.7 (1.3)	0.1 (0.2)	0.2 (0.3)	0 (-)	0.4 (0.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.5 (1.1)	2.3 (1.5)	
Runs	3	0.3 (1.1)	3.5 (6.6)	4.6 (8.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.3 (1.1)	0 (-)	0 (-)	0.3 (1.1)	3.5 (6.6)	4.9 (8.5)	
Pocket- waters	5	0 (-)	5.4 (2.8)	6.6 (2.8)	0 (-)	0.2 (0.5)	0 (-)	0.2 (0.6)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	5.4 (2.8)	7.1 (3.0)	

Table C-2. Tenmile Creek continued.

Creek-Year Section Date	n	Trout										Chinook salmon		Total			
		Fry		Rb/Sh		Cutthroat		Bull		Whitefish			Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50	51-150	150+	51-150	150+	51-150	150+	0-51	51-150	150+						
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)						
Section 4 Pools	9	0.1 (0.3)	4.7 (2.0)	2.4 (0.8)	0.5 (0.4)	0.1 (0.3)	0 (-)	0.1 (0.3)	0 (-)	0 (-)	0.1 (0.3)	0 (-)	0 (-)	0.1 (0.3)	5.2 (2.3)	2.8 (0.9)	
Riffles	13	0.2 (0.3)	3.1 (1.1)	0.3 (0.3)	0.2 (0.3)	0.1 (0.2)	0.1 (0.1)	0.1 (0.1)	0 (-)	0 (-)	0.1 (0.2)	0 (-)	0 (-)	0.2 (0.3)	3.4 (1.0)	0.6 (0.3)	
Runs	5	0.5 (0.6)	5.0 (2.3)	0.2 (0.7)	0 (-)	0 (-)	0.2 (0.6)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.5 (0.6)	5.3 (2.9)	0.2 (0.7)	
Pocket- waters	8	0.2 (0.3)	3.8 (2.1)	1.0 (0.8)	0.6 (0.7)	0 (-)	0.1 (0.3)	0.1 (0.3)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.2 (0.3)	4.6 (3.0)	1.1 (0.8)	

Table C-3 Mean fish densities (fish/100m²) by species and length class in Twentymile Creek (1980 and 1981) by species, length class, section, and habitat type (+ 95% confidence interval for densities in parentheses).

		Trout											Chinook salmon		Total		
Creek-Year Section Date	n	Fry	Rb/Sh		Cutthroat		Bull		Whitefish			Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)	
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)						
Twentymile-1980																	
Section 1																	
Pools	6	2.0 (2.1)	1.5 (2.8)	1.0 (1.3)	22.9 (14.1)	3.6 (2.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.0 (2.1)	24.4 (14.0)	4.6 (3.1)	
Riffles	2	0 (-)	0 (-)	0 (-)	2.5 (7.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (0)	2.5 (7.9)	0 (-)	
Runs	2	0 (-)	0 (-)	0 (-)	9.5 (39.8)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	9.5 (39.8)	0 (-)	
Pocket- water	7	0 (-)	1.6 (1.6)	0 (-)	5.4 (1.7)	0.8 (1.7)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	7.0 (1.3)	0.8 (1.7)	
Back- waters	2	11.2 (143.9)	0 (-)	0 (-)	11.2 (143.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	11.2 (143.9)	11.2 (143.9)	0 (-)	
Side channels	1	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	
Section 2																	
Pools	10	0.9 (0.5)	3.8 (1.2)	1.0 (0.5)	8.3 (1.6)	1.5 (0.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.9 (0.5)	12.1 (2.2)	2.5 (1.2)	
Riffles	4	0 (-)	0.4 (1.2)	0 (-)	0.7 (1.5)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1.1 (2.4)	0 (-)	
Runs	13	1.0 (0.9)	2.4 (1.0)	0.3 (0.4)	4.9 (1.3)	0.3 (0.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1.0 (0.9)	7.3 (1.6)	0.6 (0.7)	
Pocket- waters	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	
Back- waters	3	4.3 (20.7)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	4.3 (20.7)	0 (-)	0 (-)	
Side channels	2	2.0 (22.0)	2.0 (22.0)	0 (-)	7.8 (40.0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.0 (22.0)	9.8 (62.0)	0 (-)	

Table C-3 Twenty Mile Creek continued.

Creek-Year Section Date	n	Trout										Chinook salmon		Total			
		Fry		Rb/Sh		Cutthroat		Bull		Whitefish			Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)						
Section 3																	
Pools	11	6.8 (4.9)	1.2 (1.5)	0.6 (0.7)	14.9 (8.2)	2.8 (1.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	6.8 (4.9)	16.1 (9.2)	3.4 (1.5)	
Riffles	2	1.2 (16.2)	1.2 (12.2)	0 (-)	3.5 (20.3)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1.2 (16.2)	4.6 (8.1)	0 (-)	
Run	7	2.3 (3.5)	0.9 (1.4)	0.5 (1.0)	6.4 (4.1)	0.5 (1.1)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.3 (3.5)	7.4 (4.5)	0.9 (1.3)	
Pocket- waters	6	1.6 (2.1)	0 (-)	0 (-)	5.5 (4.1)	1.0 (1.4)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1.6 (2.1)	5.5 (4.1)	1.0 (1.4)	
Back- waters	2	31.6 (195.4)	10.5 (111.7)	0 (-)	52.6 (27.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	31.6 (195.4)	63.2 (139.6)	0 (-)	
Side channels	3	8.8 (8.9)	2.2 (8.3)	0 (-)	8.8 (8.9)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	8.8 (8.9)	11.1 (13.4)	0 (-)	
Section 4																	
Pools	7	3.0 (3.1)	1.5 (2.6)	0 (-)	15.1 (8.4)	0.8 (1.8)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	3.0 (3.1)	16.6 (9.5)	0.8 (1.8)	
Riffles	4	0 (-)	0 (-)	0 (-)	4.5 (6.1)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	4.5 (6.1)	0 (-)	
Runs	3	0 (-)	0 (-)	0 (-)	13.2 (43.3)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	13.2 (43.3)	0 (-)	
Pocket- waters	1	0 (-)	0 (-)	0 (-)	6.4 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	6.4 (-)	0 (-)	
Back- waters	2	0 (-)	0 (-)	0 (-)	23.8 (314.6)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	23.8 (314.6)	0 (-)	
Side channels	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	

Table C-3 Twentymile Creek continued.

Creek-Year Section Date	n	Trout										Chinook salmon		Total		
		Pry	Rb/Sh		Cutthroat		Bull		Whitefish			Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)					
Twentymile-1981																
Section 2																
Pools	10	0.1 (0.2)	0 (-)	0 (-)	0.9 (1.0)	2.8 (1.5)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.1 (0.2)	0.9 (1.0)	2.8 (1.5)
Riffles	9	0 (-)	0 (-)	0 (-)	0 (-)	0.4 (1.2)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.4 (1.2)
Runs	12	0 (-)	0 (-)	0 (-)	0.7 (0.6)	1.2 (1.0)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.7 (0.6)	1.2 (1.0)
Pocket- waters	0	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Section 3																
Pools	11	2.7 (4.2)	0 (-)	0 (-)	11.6 (7.1)	8.4 (4.5)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2.7 (4.2)	11.6 (7.1)	8.4 (4.5)
Riffles	1	0 (-)	0 (-)	0 (-)	5.4 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	5.4 (-)	0 (-)
Runs	7	0.7 (1.3)	0.4 (0.9)	0 (-)	10.8 (7.1)	6.0 (6.6)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0.7 (1.3)	11.2 (7.8)	6.0 (6.6)
Pocket- waters	6	0 (-)	0 (-)	0 (-)	7.7 (6.2)	5.1 (8.6)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	7.7 (6.2)	5.1 (8.6)

Table C-4. Mean fish densities (fish/100m²) by species and length class in Mill Creek (1979 and 1980) by species, length class, section, and habitat type.

Creek-Year Section Habitat	n	Trout										Chinook salmon		Total		
		Fry	Rb/Sh		Cutthroat		Bull		Whitefish							
		0-50	51-150	150+	51-150	150+	51-150	150+	0-51	51-150	150+	Age	Age			
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	0	I	(mm)	(mm)	(mm)
Mill-1979																
Section 1																
Pools	5	25.6	3.9	0.7	0	0	0	0	0	0	0	0	0	25.6	3.9	0.7
Riffles	2	18.9	0	0	0	0	0	0	0	0	0	0	0	18.9	0	0
Runs	1	21.7	2.2	2.2	0	0	0	0	0	0	0	0	0	21.7	2.2	2.2
Pocket- waters	5	16.5	3.5	1.0	0	0	0	0	0	0	0	0	0	16.5	3.5	1.0
Mill-1980																
Section 1																
Pools	5	32.8	23.0	0.7	0	0.7	0	0	0	0	0	0	0	32.8	23.0	1.3
Riffles	2	31.5	6.3	0	0	0	0	0	0	0	0	0	0	31.5	6.3	0
Runs	1	65.1	22.0	2.2	0	0	0	0	0	0	0	0	0	65.1	22.0	2.2
Pocket- waters	5	32.8	17.5	0.8	0.2	0	0	0	0	0	0	0	0	32.8	17.7	0.8

Table C-4. Mean fish densities (fish/100m²) by species and length class in Mill Creek (1979 and 1980) by species, length class, section, and habitat type.

		Trout										Chinook salmon		Total			
Creek-Year Section Habitat	n	Fry		Rb/Sh		Cutthroat		Bull		Whitefish			Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)						
Mill-1979																	
Section 1																	
Pools	5	25.6	3.9	0.7	0	0	0	0	0	0	0	0	0	25.6	3.9	0.7	
Riffles	2	18.9	0	0	0	0	0	0	0	0	0	0	0	18.9	0	0	
Runs	1	21.7	2.2	2.2	0	0	0	0	0	0	0	0	0	21.7	2.2	2.2	
Pocket- waters	5	16.5	3.5	1.0	0	0	0	0	0	0	0	0	0	16.5	3.5	1.0	
Mill-1980																	
Section 1																	
Pools	5	32.8	23.0	0.7	0	0.7	0	0	0	0	0	0	0	32.8	23.0	1.3	
Riffles	2	31.5	6.3	0	0	0	0	0	0	0	0	0	0	31.5	6.3	0	
Runs	1	65.1	22.0	2.2	0	0	0	0	0	0	0	0	0	65.1	22.0	2.2	
Pocket- waters	5	32.8	17.5	0.8	0.2	0	0	0	0	0	0	0	0	32.8	17.7	0.8	

Table C-5. Mean fish densities (fish/100m²) by species and length class in West Fork Red River (1979 and 1980) by species, length class, section, and habitat type.

Creek-Year Section Habitat	n	Trout								Whitefish			Chinook salmon		Total			
		Fry			Rb/Sh		Cutthroat		Bull		0-51 (mm)	51-150 (mm)	150+ (mm)	Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)										
West Fork Red River-1979																		
Section 1																		
Pools	5	42.4	0.8	0	7.1	2.2	1.9	0.5	0	0	1.4	0	0	42.4	9.9	4.1		
Riffles	2	72.8	0	0	3.9	0	0	0	0	0	0	0	0	72.8	3.9	0		
Runs	2	45.1	0	0.9	6.2	0	0.9	0	0	0	0	0	0	45.1	7.1	0.9		
Pocket- waters	4	35.8	0.8	0	3.0	0	0.4	0	0	0	0.4	0	0	35.8	4.2	0.4		
West Fork Red River-1980																		
Section 1																		
Pools	5	0	5.5	0	3.0	2.2	0.3	0	0	0	0.8	0	0	0	8.8	3.0		
Riffles	2	0	1.3	0	0	0	0	0	0	0	0	0	0	0	1.3	0		
Runs	2	0	5.3	0	3.5	1.8	0	0	0	0	0	0	0	0	8.8	1.8		
Pocket- waters	4	0.8	4.6	0	3.0	0.4	0	0	0	0	0.4	0	0	0.8	7.6	0.8		

Table C-6 Mean fish densities (fish/100m²) by species and length class in Trapper Creek (1979, 1980 and 1981) by species, length class, section, and habitat type.

Creek-Year Section Habitat	n	Trout								Whitefish			Chinook salmon		Total		
		Fry	Rb/Sh		Cutthroat		Bull		Age 0				Age 1				
		0-50 (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	51-150 (mm)	150+ (mm)	0-51 (mm)	51-150 (mm)	150+ (mm)						
Trapper-1979																	
Section 2																	
Pools	8	0.7	1.4	2.0	12.9	4.1	0	0	0	0	0	0	0	0.7	14.9	6.1	
Riffles	3	0	0	0	5.2	0	0	0	0	0	0	0	0	0	5.2	0	
Runs	3	0	0	0	19.5	0	0	0	0	0	0	0	0	0	19.5	0	
Pocket- waters	5	1.4	0	0	8.2	0	0	0	0	0	0	0	0	1.4	8.2	0	
Trapper-1980																	
Section 2																	
Pools	8	2.7	2.0	0	12.9	6.8	0	0	0	0	0	0	0	2.7	14.9	6.8	
Riffles	3	0	2.6	0	10.3	0	0	0	0	0	0	0	0	0	12.9	0	
Runs	3	0	1.9	0	13.6	3.9	0	0	0	0	0	0	0	0	15.6	3.9	
Pocket- waters	5	2.1	1.4	0	9.6	0.7	0	0	0	0	0	0	0	2.1	11.0	0.7	
Section 3																	
Pools	7	4.0	0.7	0.4	6.6	3.7	0.4	0	0	0	0	0	0	4.0	7.7	4.0	
Riffles	3	4.3	0	0	2.9	0	0	0	0	0	0	0	0	4.3	2.9	0	
Runs	5	2.6	0.9	0	13.0	0.9	0	0	0	0	0	0	0	2.6	13.8	0.9	
Pocket- waters	3	3.5	0.7	0	7.1	0.7	0	0	0	0	0	0	0	3.5	7.8	0.7	
Trapper-1981																	
Section 2																	
Pools	8	0.7	0	0	12.8	2.7	0	0	0	0	0	0	0	0.7	12.8	2.7	
Riffles	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Runs	3	0	0	0	13.6	1.9	0	0	0	0	0	0	0	0	13.6	1.9	
Pocket- waters	5	1.1	0	0	8.5	0.7	0	0	0	0	0	0	0	1.1	8.5	0.7	

Table C-6 Trapper Creek continued.

Creek-Year Section Habitat	n	Trout										Chinook salmon		Total			
		Fry		Rb/Sh		Cutthroat		Bull		Whitefish			Age 0	Age I	0-50 (mm)	51-150+ (mm)	150+ (mm)
		0-50	51-150	150+	51-150	150+	51-150	150+	0-51	51-150	150+						
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)					
Section 3																	
Pools	7	2.6	0	0	2.2	2.9	0	0	0	0	0	0	0	2.6	2.2	2.9	
Biffles	3	0	0	0	1.4	0	0	0	0	0	0	0	0	0	1.4	0	
Runs	5	0	0	0	2.6	0.9	0	0	0	0	0	0	0	0	2.6	0.9	
Pocket- waters	3	0	0	0	2.1	0.7	0	0	0	0	0	0	0	0	2.1	0.7	

APPENDIX D
"Habitat-Fish Relationships"

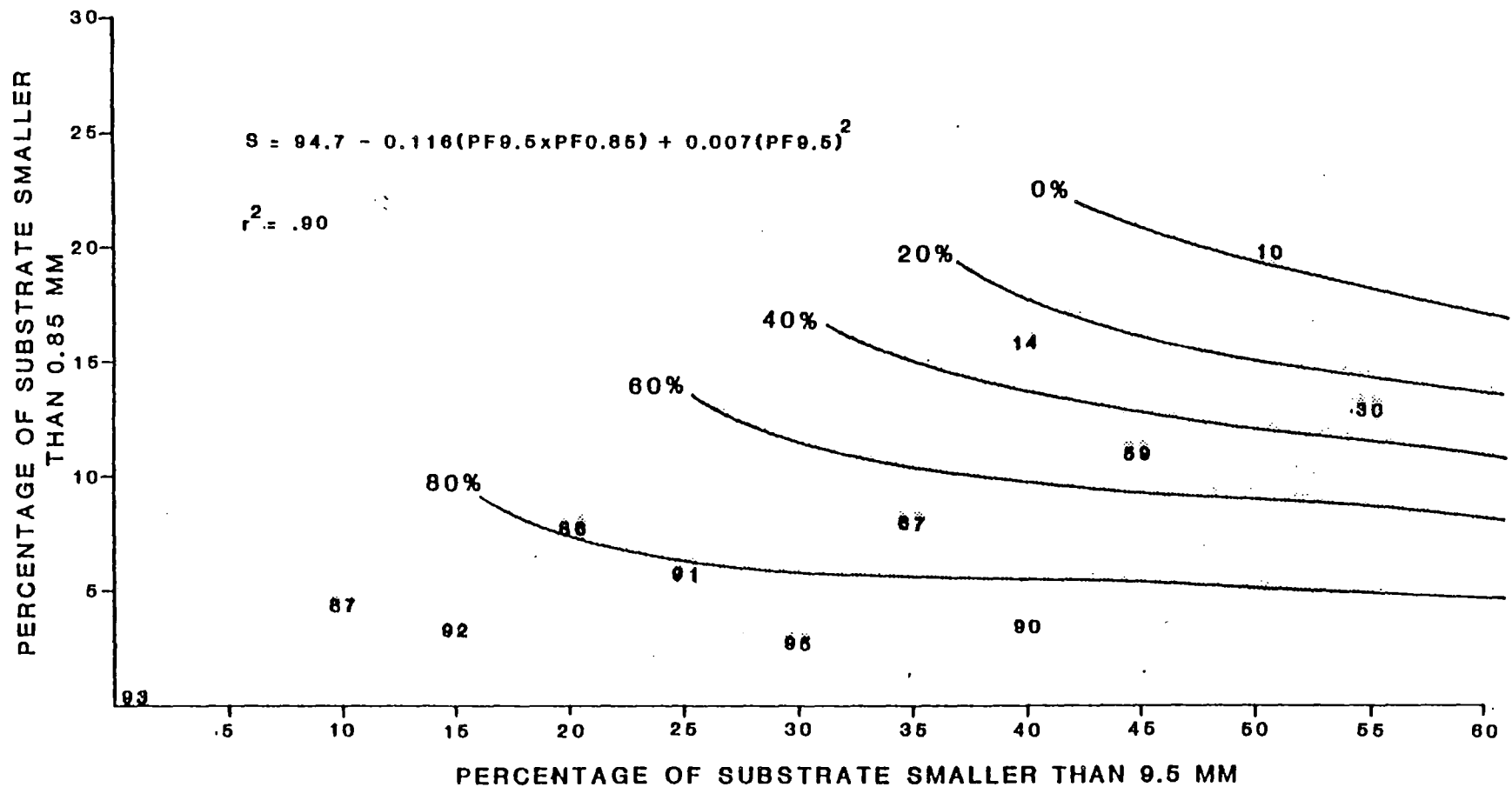


Figure D-1. Bands showing steelhead embryo survival predictions (80%, 60%, 40%, 20%, 0%) overlying range of natural spawning gravel. Scattered numbers are percent survival values from laboratory incubation tests.

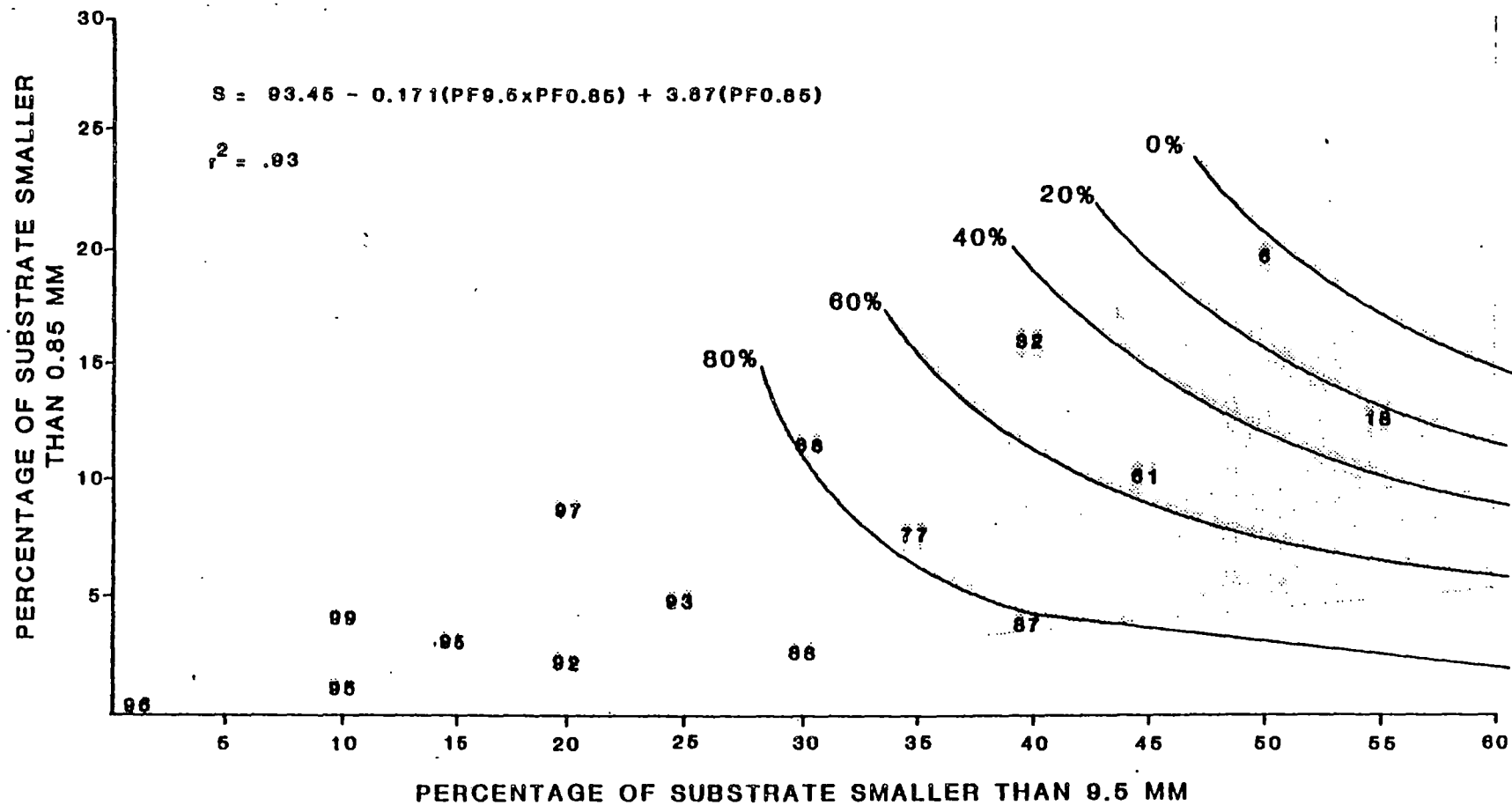


Figure D-2. Bands showing chinook salmon embryo survival predictions (80%, 60%, 40%, 20%, 0%) overlying range of natural spawning gravel. Scattered numbers are percent survival values from laboratory incubation tests.

SUMMER REARING CAPACITY

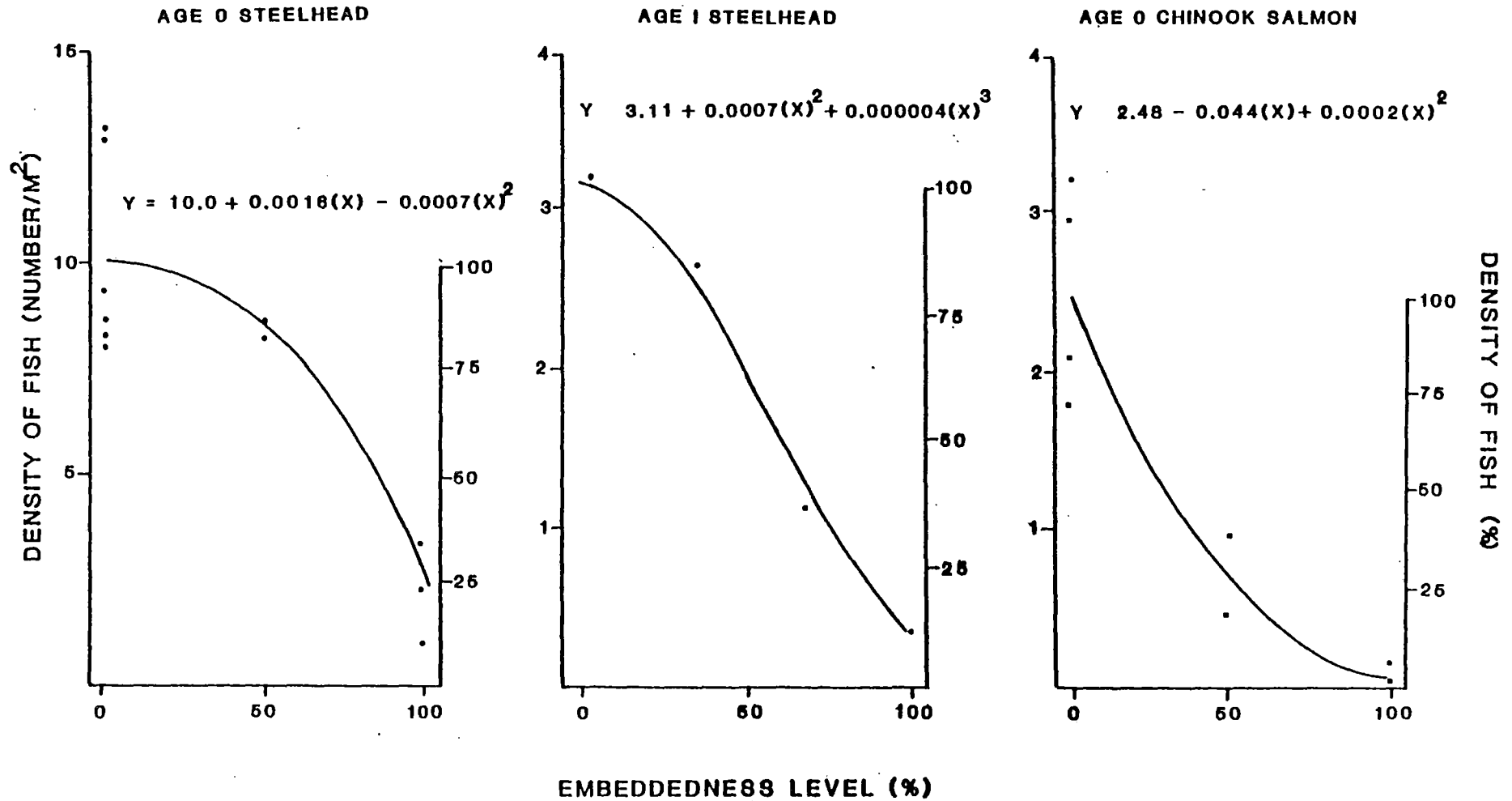


Figure D-3. Relationship between summer rearing capacity (density of fish in numbers of fish/m² and as a percentage) and substrate embeddedness in runs for age 0 and 1 steelhead trout and age 0 chinook salmon (Klamt 1976).

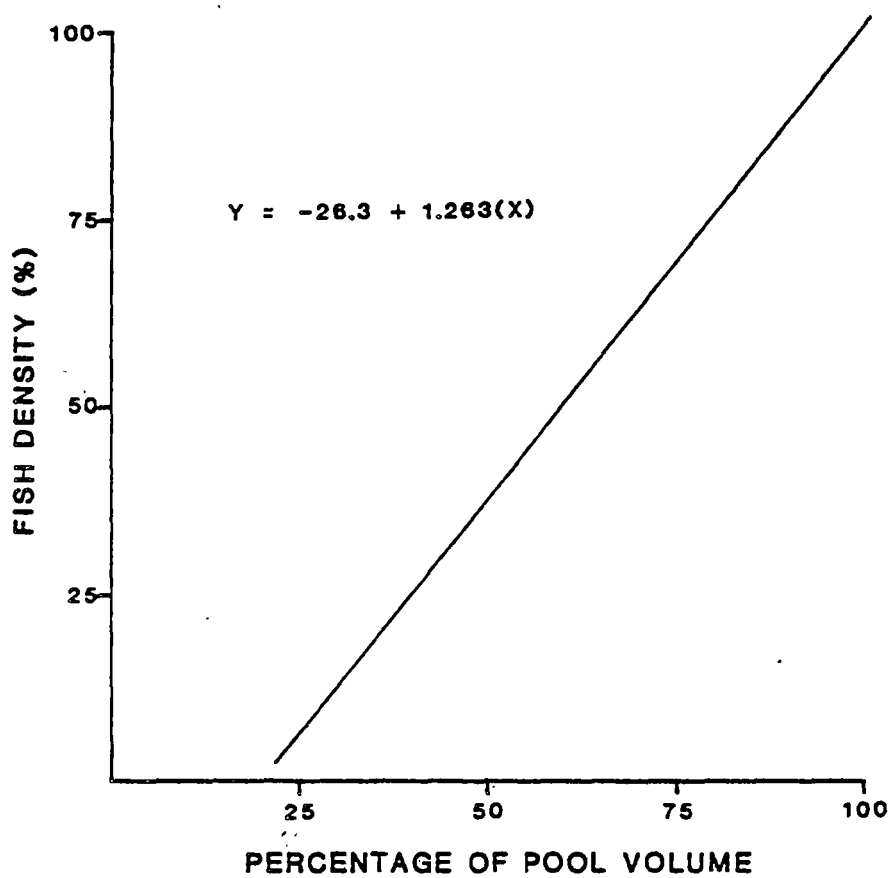


Figure D-4. Relationship between pool volume and summer fish density in pools (modified from Bjornn, 1977). Adjusted so that pool volume is 100% when fish densities are at capacity.

"POOL"

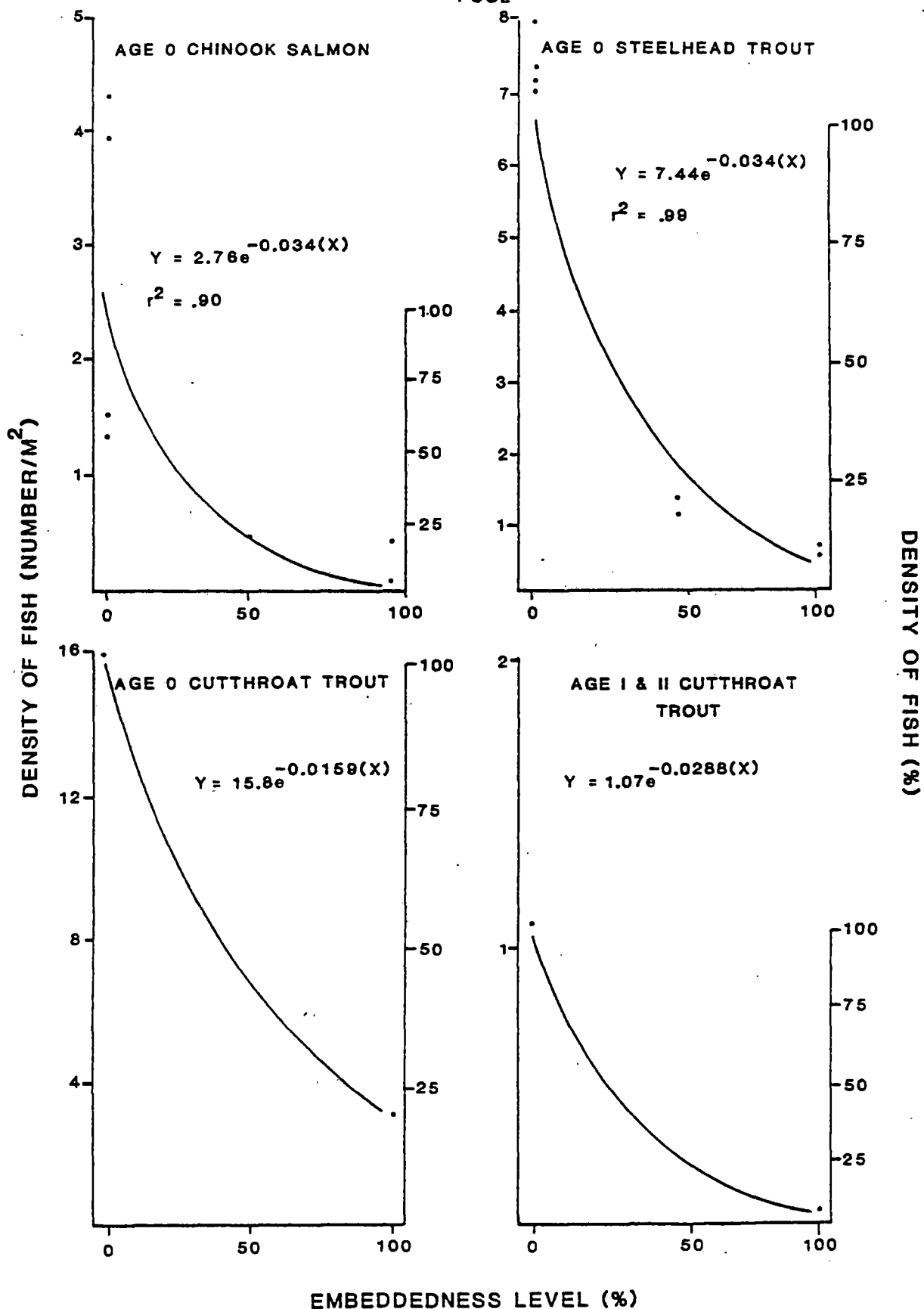


Figure D-5. Relationship between winter carrying capacity of pools (density of fish in numbers of fish/m² and as a percentage) and substrate embeddedness for age 0 chinook salmon, steelhead, and cutthroat trout and age I and II cutthroat trout.

SH 177 L63 F5		#126 9-83 "2"
AUTHOR		
J.S. Irving and others		
TITLE "Fish Resources in the Gospel- Hump Area of Central Idaho..."		
DATE DUE	BORROWER'S NAME	

**INTERMOUNTAIN FOREST
AND RANGE EXP. STATION**
507 25th Street
Ogden, Utah 84401